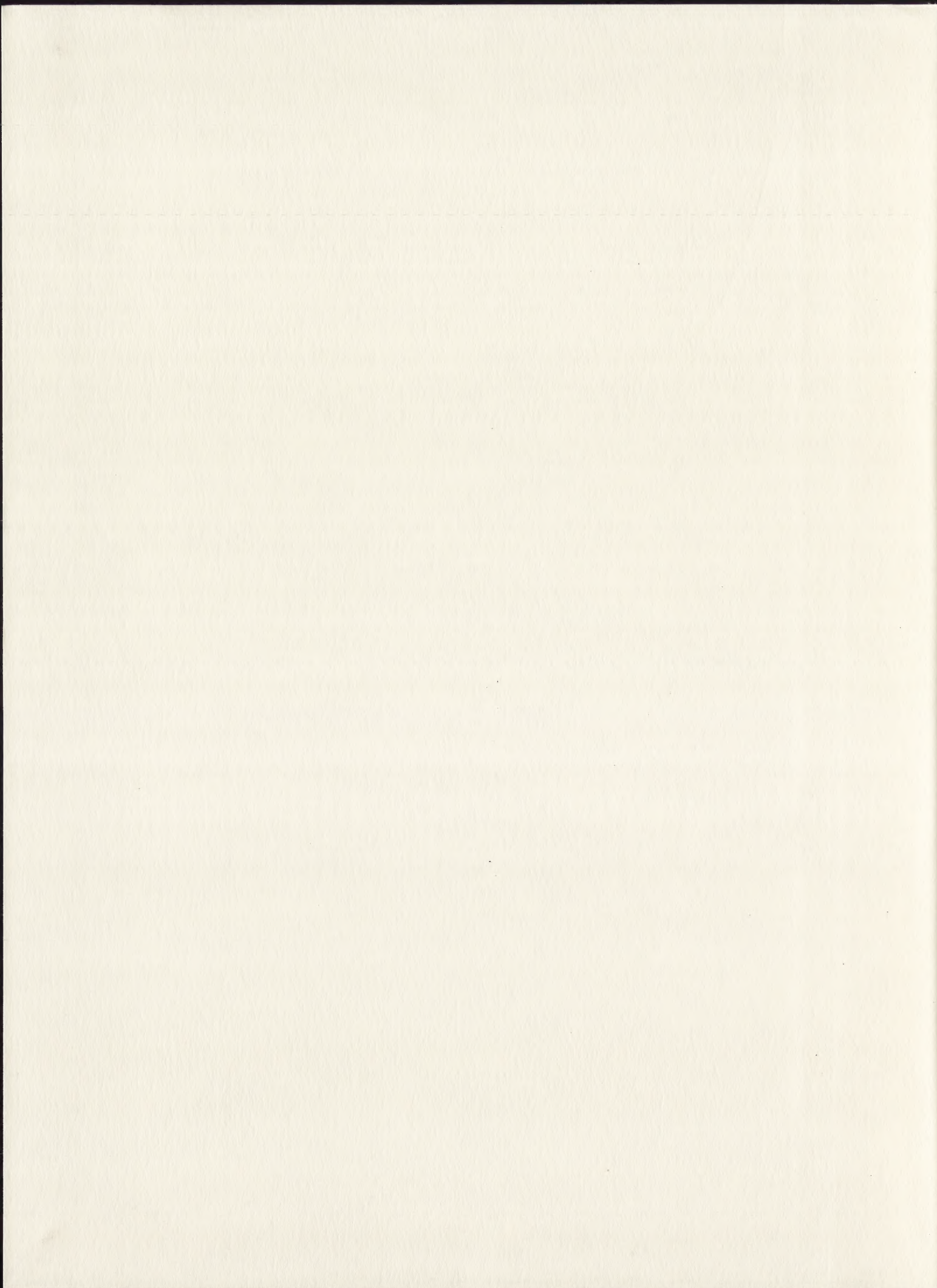


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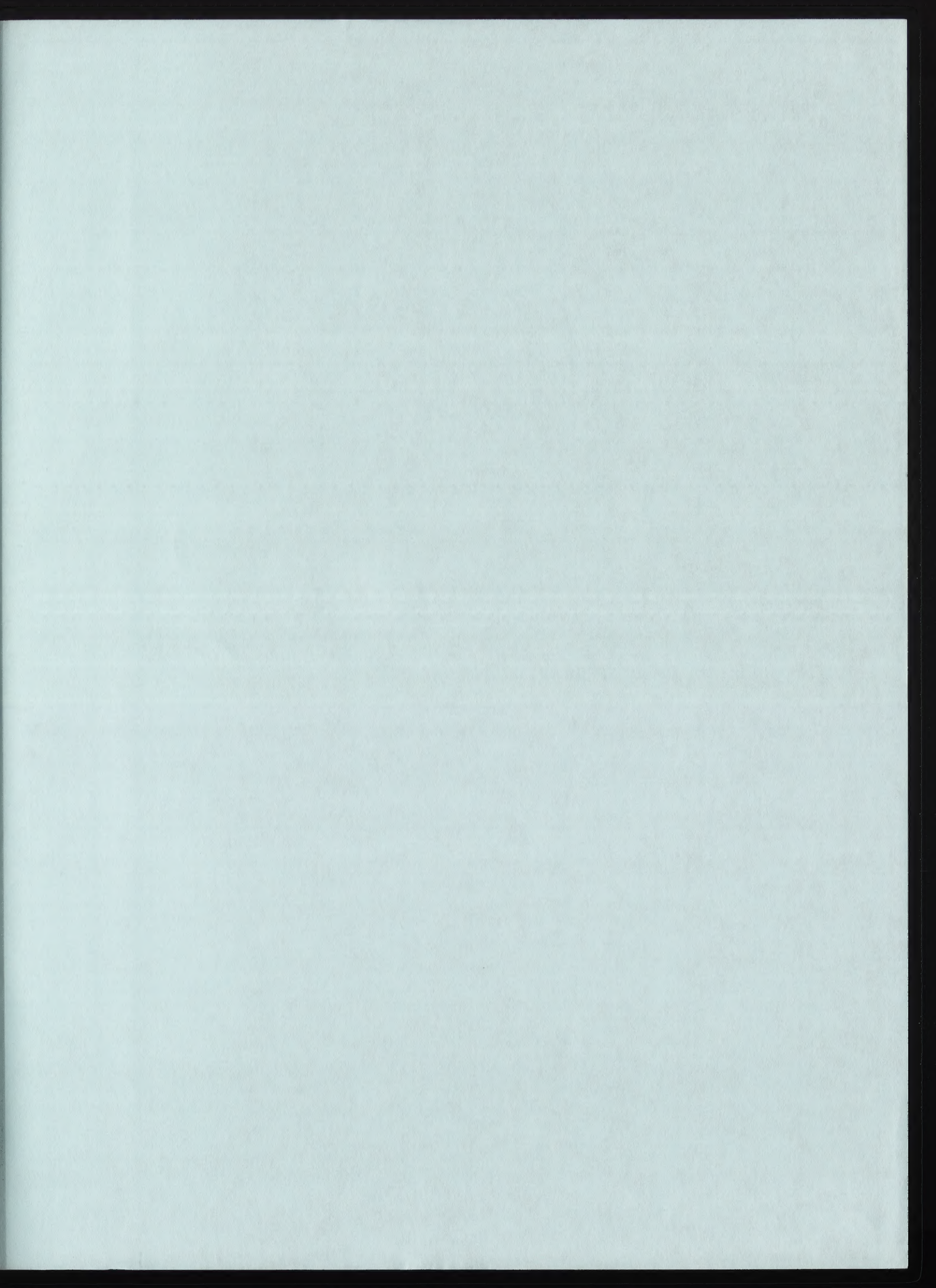
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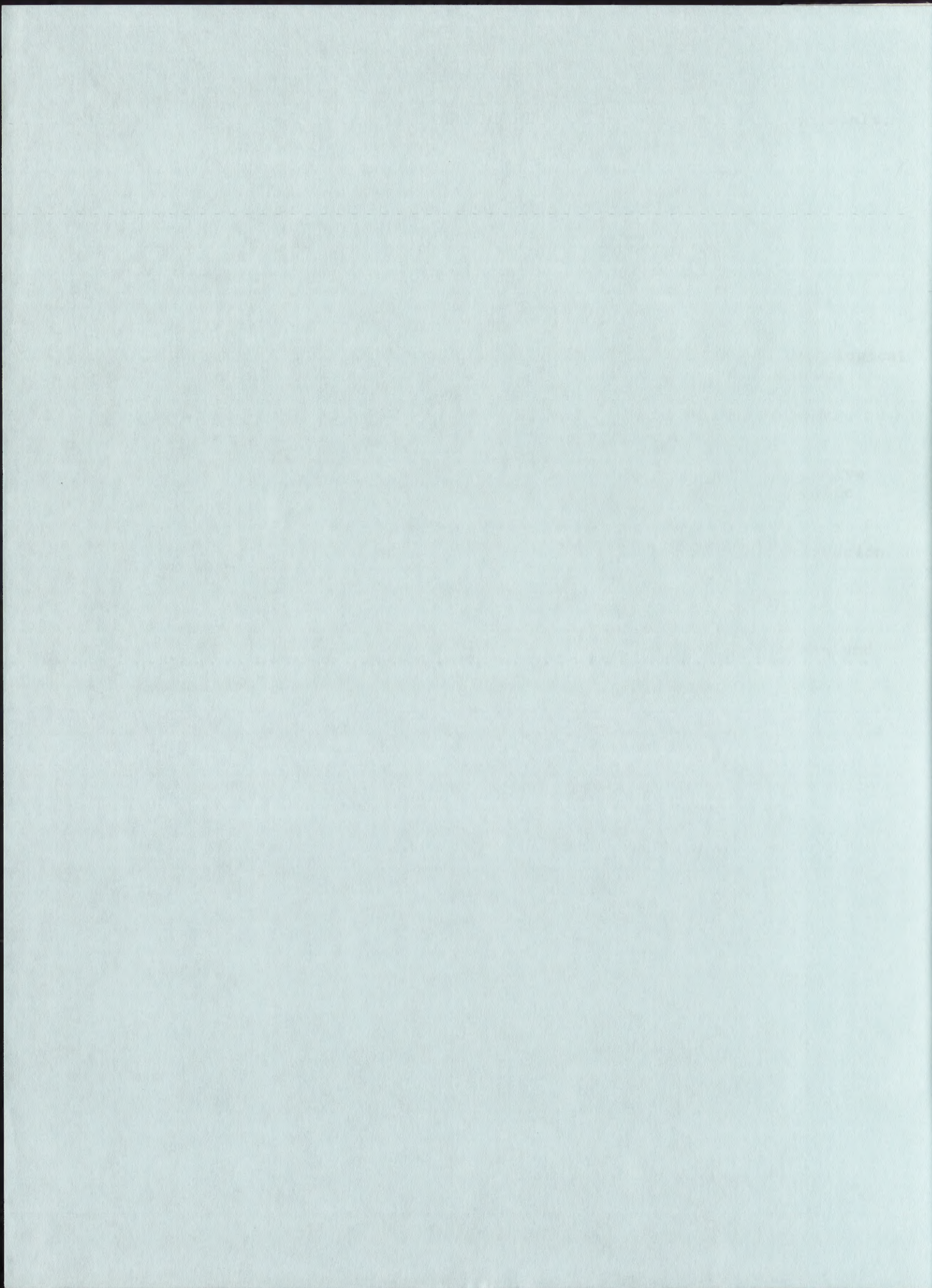
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ON THE OCCURRENCE OF RED DYESTUFFS IN TEXTILE MATERIALS FROM
THE PERIOD 1450 - 1600

ORIGIN	CHEMICAL CONSTITUTION	IDENTIFICATION
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-JUDITH H.HOFENK - DE GRAAFF
WILMA G.Th. ROELOFS

I C O M

INTERNATIONAL COUNCIL OF MUSEUMS	/	CONSEIL INTERNATIONAL DES MUSÉES
COMMITTEE FOR CONSERVATION	/	COMITÉ POUR LA CONSERVATION

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1972

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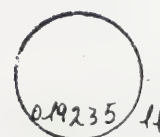
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CENTRAL RESEARCH LABORATORY FOR OBJECTS OF ART AND SCIENCE, AMSTERDAM

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1. Introduction

From the earliest times, man could dye brilliant and fast reds with Kermes, Cochineal or Madder together with aluminium mordants. These dyestuffs were used very frequently; redwoods and archil were also used but these dyes are not so fast to light (11).

Kermes and Cochineal are both extracts from insects of the coccus family and chemical constitutions resemble each other. However the geographic distribution of the two insects and that of the dyes is very different. Kermes originates in Southern Europe, the Levant and the near East (3), Cochineal in South America and Mexico.

Before the discovery of America in 1492, only Kermes was known in Europe, together with Madder and Brasilwood.

It would seem from the literature that already fifty years after the introduction of Cochineal, Kermes was superseded on the European market and hardly used any more (2,3,6,10). The presence of Kermes or Cochineal in a textile object could therefore in principle provide a date guess given for that object. It was thought however that additional proof was required to confirm the assertion that Kermes disappeared so quickly after 1492.

It was therefore decided to identify the red-dyestuffs in a great number of samples from well-dated textile materials in a period including the date of discovery of America.

The analytical method used, allowed the identification of other red-dyestuffs then Kermes; it was therefore attempted to obtain some information on the occurrence of red-dyestuffs over the period 1450 - 1600 and their geographic location. Although some 250 samples were analyzed no statistical value is claimed for the results, because some important factors are unknown e.g. the original population and the present population.

2. Method of Analysis (10)

Thin layer chromatography (14,18) was chosen to analyse dyestuffs on textile material. This method was found preferable to e.g. infrared spectrophotometry.

Reason herefore are as follows; on a research like this for which one has to work up a great number of samples it is necessary to keep the procedure of sample-preparation simple in the first place. By means of standard reference materials it should be possible to identify dyestuffs rapidly. In this case T.L.C. does meet these requirements entirely.

Sample preparation is very simple and the solvent-system for dyestuffs already was known by previous researches (10,14).

Eventually present impurities do not do any harm to the thin layer chromatograms. Sample-preparation for infrared

spectrometry is much more complicated and the spectrum is very much disturbed by impurities present. With these old

samples one very often could speak of mixtures and other additions that could disturb the spectrum. In this respect one does not have any trouble with chromatography.

With the red-dyestuffs however the chemical composition does show a great similarity, e.g. Madder, Cochineal and Kermes all belong to the anthracene-group; still they are very well to be separated by means of thin layer chromatography.

2.1 Sampling

In a previous research it appeared that one just needed a small thread of 0,5 cm or even less to analyse the dyestuff by means of thin layer chromatography.

In many cases one can take away such a thread from the back of the textile. Especially on carpets this does not give any trouble, for on the back often casted off fibres do occur, thus no damage can be done to the object. There is no objection whatsoever to take such a kind of sample from flat textiles and embroideries; there will be done no damage to the textile object. The sample can be taken away very easily with a pair of small scissors or a small knife

On the request of the authors, to send well-dated small samples of textiles from their collection, a great number of European museums and institutes were so kind as to react positively. With some exceptions samples were taken by the owners or curators of their own collection.

The authors are very grateful for the cooperation given to them on obtaining the samples for their research. Without this cooperation research could not have been effected.

Deutsches Tapeten Museum, Kassel Herr Josef Leisz
Erzbischöfliches Diözesan Museum, Köln Dr W. Schulten
Gewebesammlung der Stadt Krefeld, Krefeld Dr Renate Jaques
Oesterreichisches Museum für Angewandte Kunst, Wien
Dr Dora Heinz
Kunstgewerbe Museum, Berlin Dr Barbara Mundt
Abegg- Stiftung Bern, Riggisberg (Bern) Frau Flury-Lemberg
Schweizerisches Landesmuseum, Zürich, Dr Jenny Schneider
Gewerbe Museum Basel, Basel, Dr I. Peter-Müller
Musées Royaux d'Art et d'Histoire, Brussel Dr J.P. Asselberghs
Rijksmuseum, Amsterdam de heer Bloedhouwer/Hr C.A. Burgers
Aartsbisschoppelijk Museum, Utrecht Drs A. Janssens
Kongl. Livrustkammaren, Stockholm, Miss Gudrun Ekstrand
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Museum of Fine Arts, Boston, Mrs. Edward L.B. Terrace
Metropolitan Museum of Art, New York City, Jean Maily
Kunstindustrimuseum - i - Oslo, Oslo Miss Elsa Tharaldsen
Muzeum Narodowe, Warsaw, Mrs. M. Markiewicz
Muzej za Umjetnost i Obrt, Zagreb, Mrs. Vanda Pavelic-Weinert
Conservation of Textiles, London, Mrs. Karen Finch
Museo Textil Barcelona, Barcelona, Mrs. Pilar Tomas
Musée Historique des Tissus, Lyon, R. de Micheaux
Soprintendenza alle Gallerie, Firenze, Prof Alfredo Clignon
Musea Nacional de Arte Antiga, Lisbon, M.J. de Mendonça

2.2 Analytical Procedure

About 5 mg of the sample is required for the analysis.
The sample is boiled a few minutes with 10% hydrochloric acid.
Because almost all red-dyestuffs are mordant-dyestuffs and are present on the fibre bound to aluminium or tin oxide, it is necessary to hydrolyze this composition, otherwise the dyestuff will remain on the fibre and will be insoluble.

After hydrolysis the fibre is moved together with the hydrochloric acid to a micro extraction apparatus with a total volume of 2 ml. The apparatus has been constructed according to the authors design (fig. 15). With 2 ml methylalcohol the hydrolyzed sample is extracted during one hour in the abovementioned apparatus. The extract will be concentrated to about 1 ml after the extraction, and this solution in which the dyestuff is present, is used for the analysis.

For the thin layer chromatography acetylated cellulose is used as carrier material.

Ready to hand plates from Messrs Macherey & Nagel: type Cel 300 AC 10 are used. The plates are pre-washed once with the eluent concerned, this to remove all impurities that might occur on the plates. The eluent that is used, is according to Stahl (18): /Tetrahydrofurane/Ethylacetate/Water/35:6:45/.

All chemicals have to be of the highest purity, to prevent side reaction. A so called Pasteur capillary is used to apply the extracted dyestuff solution to the plate. Its tip is more specially pulled out to a very small tip, with an internal diameter of about 100 micron, so that 1ul can be brought on the plate. After elution the arisen "spots" are sprayed with a 0,5 normal solution of KOH, observed and identified in ultra-violet light with a wavelength of 350 mu. Immediately Polaroid positive colour pictures are made with a Polaroid technical camera MP₃. A type RO orange filter is used.

2.3 Standards

For identification a number of standard materials is used which run simultaneously with the unknown samples on each plate.

These are:

Madder	:from Rubia tinctoria
Kermes	:from Coccus ilicis L. prepared by Prof O. Dimroth
Polish Cochineal	:from Magarodes polonicus: by the courtesy of Mr. D.H. Abrahams. Dexter Chemical Corporation
Cochineal	:from Coccus cacti L. Doerner Institute Munich

Brasilwood	: from <i>Caesalpinia sappan</i> : by the courtesy of the Royal Tropical Institute, Amsterdam
Redwood	: Rotholzlack, Doerner Institute, Munich
Lackdye	: from <i>Coccus lacca</i>
Red Sandalwood	: from <i>Pterocarpus santalinus</i> L.
Sumach	: from <i>Rhus coriaria</i> L.

3. Origin of the most frequently used red-dyestuffs

3.1 Madder (17)

Madder is one of the oldest and most frequently used red-dyestuffs in Europe. From ancient times it has been mentioned in descriptions of daily life in the ancient world and quoted in many other documents (Pliny, Herodote).

Madder was known in Persia, Arabia and Mesopotamia. Recipes for dyeing with Madder can be found in the Papyrus Greacus Holmiensis.

Madder was obtained from the roots of the *Rubia tinctoria* L; this plant is indigenous in Syria, Palestine and Egypt. Also used was the *Rubia peregrina*, a plant from Persian origin, which was introduced into Spain by the Arabs.

Madder was cultivated for textile dyeing from early times in the neighbourhood of Ravenna and Caria.

In the seventh Century A.D. it was cultivated at Saint Denis near Paris. Later in the 14th Century, the quality of Madder came from Holland, on the islands of Zeeland, where large crops were grown. After the regulations of Colbert in 1669 the cultivation of Madder in France also became famous, particularly in Avignon. In the 19th Century, some time before the discovery of the first synthetic dyestuff (Mauveïn, 1862, by Perkin) there were many places all over the world, where Madder was cultivated.

In Holland the cultivation of Madder was bound by curious rules; the time of dibbling was strictly fixed, and so was the harvesting. There were various qualities of Madder on the market, more or less finely sifted. The quality of the oriental Madder is much better than that of the European variety, owing to the larger percentage of real dyestuff in the roots of the

former plant.

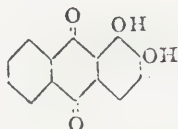
Madder gives a fast colour only when the yarns or cloth have been mordanted before dyeing, with one of several salts of metals. Alum principally was used and in early times almost exclusively; however iron salts also have been used. In the 17th Century the mordanting after Drebbel with Tin-salts was used (6).

The roots of the *Rubia tinctoria* L. contain various glucosides of Alizarine and Purpurin.

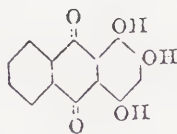
The glucosides are hydrolyzed during the dyeing procedure. The colouring matters are Alizarin and Purpurin. Purpurin is inferior to Alizarin and a dyed textile of good quality will have a low content of Purpurin.

The chemical composition is: (1,12,13).

Alizarin, $C_{14}H_8O_4$



Purpurin, $C_{14}H_8O_5$



3.2 Kermes (3,5,10)

The discovery of scarlet dyeing with Kermes can be attributed with great certainty to the Phoenicians (3), who had practised purple dyeing from antiquity and had a good knowledge of the techniques of dyeing. The earlier Greeks also considered the Phoenicians the most important dyers of Kermes. It is mentioned by Pliny and Herodote (13).

Kermes was an expensive dyestuff and therefore it was only used to dye high quality textiles, particularly silk.

Pliny named as the principal countries of origin: Africa, Asia minor, Greece and Spain.

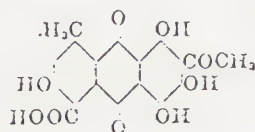
From Spain dyeing by means of Kermes spread all over Europe. The dyestuff is extracted from the dried bodies of the females of the insect *Coccus ilicis*, living on the Kermes oak, *Quercus coccifera*. They are found adhering to the twigs of the tree, resembling bluish and covered with whitish powder.

The insects (or different kind of *Coccus*) are also found on a sort of grass, in the Valley of Ararat, mentioned as early as 714 B.C. (5). The insects are collected as soon as their eggs are on the point of hatching, killed by exposure to steam or hot vinegar and dried. The product then has the appearance of pale reddish brown grains.

Like Madder, Kermes is a mordant dyestuff; wool or silk had to be prepared before dyeing with a solution of metal salt, mostly alum. After this preparation the real dyebath was made, consisting of Kermes, Winestone, arsenic and edible mushroom (15). The latter was used for its large tannin content and for causing fermentation. The colouring matter of Kermes is Kermesic acid, which exists in Kermes in the form of a salt (5.12.13).

Also present in a small quantity (0,06%) is flavo-kermesic acid.

Kermesic acid, $C_{18}H_{12}O_9$

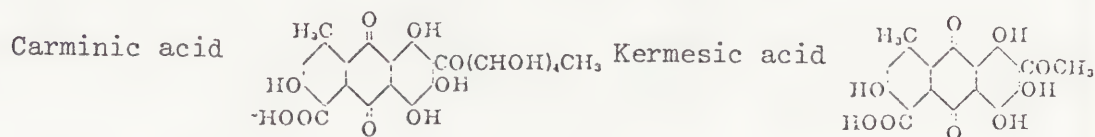


3.3 Polish Cochineal

In the Middle and Eastern Europe there was a different variety of Kermes, the so called Polish Cochineal or Saint John's grains, prepared from the bodies of the females of *Magarodes polonicus* L. This scale insect lives on the roots of the *Scleranthus porennis*, which is native in the sandy areas of East Europe. Poland, Lithuania and the Ukraine especially were rich in this variety, but it is also indigenous in Germany. The insect is slightly smaller than the Kermes insect.

Besides this kind of Coccus there were two kinds of scale insects in Russia which were gathered for dyeing red, viz. the Coccus fragariae and the Coccus uveaursi, which lives on the barberry and the strawberry. In Armenia the scale insect Porphyrophora-Hainlie was used for this purpose. The dyeing method for Polish Cochineal is the same as for Kermes.

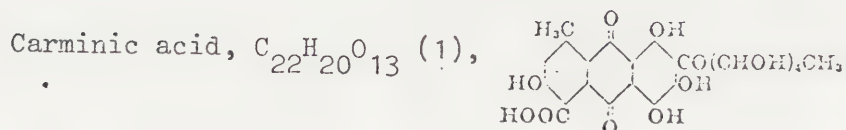
It is said that the chemical constitution of Polish Cochineal is the same as Cochineal (4), but in fact it is a mixture of carminic acid and Kermesic acid.



3.4 Cochineal (4,6,10)

Although it is supposed that Cochineal was unknown till the discovery of America by the Spaniards, it is said that a certain kind of Cochineal had been mentioned already by the Assyrians as coming from the Ararat Valley. However, this was not a kind of Cochineal but a kind of Kermes. The dyestuff is - just like Kermes - of animal origin and is obtained from the female beetles of the Coccus cacti L., which are found on different varieties of cacti, among them the Opuntia coccinellifera Mill: the Country of origin is Mexico. In Europe Cochineal was imported very shortly after the discovery of Mexico, for the first time in 1518 and already in 1523 the Spanish King inquired about the culture of Cochineal. In 1540 Cochineal was already an article of commerce in Antwerp. After 1585 it was mentioned more than once in the dyers handbooks in Amsterdam and Leyden (9). Among Cochineal there are two grades on the market, the cultivated variety or Mesteck Cochineal and a wild variety, the Grana silvestra. The first mentioned variety is twice as large as the second and yields more dyestuff. Two shades of red are obtained upon wool and silk with Cochineal, namely Crimson, which is produced by means of Alum, and after Drebbel's

discovery of the tin mordant, a scarlet with stannic salts (6).
The colouring matter in Cochineal is Carminic acid.



3.5 Redwoods (10,16)

Redwoods can be divided into two groups, viz the soluble and the insoluble Redwoods.

The frequently used Redwoods are the soluble Redwoods and among these, Brasilwood is the most frequently used dyestuff.

Brasilwood

Long before the discovery of South America, Brasilwood was already known in Europe being imported from Eastern Asia along the well known Silk-route.

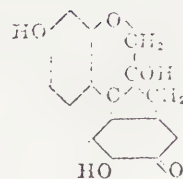
About 1190 a Spaniard named Kimichi wrote about dyewoods called Bresil or Brasil (16). Also in old German recipes Brasil (Preiselig) was mentioned in the 10th Century.

At the same time of Marco Polo (1271-1290) Brasilwood from Ceylon became known. Afterwards, about 1350, the Redwoods from Java and the surrounding islands became known under different names. In the dyers' handbooks of the Middle Ages Brasilwood was named besides Madder as a frequently used dyestuff (8,15). Brasilwood was imported in the form of large blocks, these blocks had to be rasped into smaller pieces for two reasons; in the first place, the dyestuff which was present as brassillin had to be oxidized into Brasilein by oxygen in the air and in the second place, the developed Brasilein had to be extracted with water from the wood.

Brasilwood also is a mordant dyestuff, the mordant most used was Alum, later Sumach, Tin and Ironsalts were also used.

The colouring matter of Brasilwood is:

Brasilein, $C_{16}H_{12}O_5$ (1,12,13)



Under the name of Brasilwood certain varieties of the so called "soluble" redwoods are known. These soluble redwoods give a bright red shade, which in each case is derived from one and the same colouring matter. All are botanically allied in that they are extracted from the wood of various species of *Caesalpinia*. About nine varieties have been employed as dyestuffs, of which the following are the best known.

Fernambuco or Pernambuco wood is considered to be the richest in colouring matter. It is extracted from the *Caesalpinia crista*, a tree which is abundant in Jamaica and Brasil. The true Brasilwood is derived from the *Caesalpinia brasiliensis*, and is said to contain only-half the colouring matter which is present in Fernambuco wood.

Sappanwood is obtained from the *Caesalpinia sappan*, a tree which is common to the warmer regions of Asia. The so called Limawood is a variety of Sappan, and the dyewood imported from the Philippine Islands gives an inferior quality of dyestuff.

Peachwood is the product of the *Caesalpinia echinta*, which occurs in the Central America and the Northern parts of South America. These woods, which are very hard, and of deep red colour, come into the market in the form of billets varying in weight.

Some varieties of the abovementioned woods, were employed for dyeing purposes long before the discovery of America. Although it is said that the chemical constitution of the redwoods is the same, in analysis the various redwoods they give different results. For example *Caesalpinia sappan*, which has been used in Europe long before the discovery of America, is different from *Caesalpinia brasiliensis*. At the moment it is not clear what the cause of these differences could be, however, the dyeing properties of the redwoods are the same.

4. Results

Sample number	Collection	Description of the object	Material	De
6 1)	Gewerbe Museum, Basel	Silk velvet Department Historisches Museum/ 1907/114	Silk	at
7	Gewerbe Museum, Basel	Brocatelle Department Historisches Museum/ 1907/105	Silk	16
8	Gewerbe Museum, Basel	Silk weave 1907/125	Silk	En
9	Gewerbe Museum, Basel	Silk damask 1907/93	Silk	13
10	Gewerbe Museum, Basel	Linen embroidery 1967/st. 25	Silk	16
11	Gewerbe Museum, Basel	Linen embroidery 1967/st37	Silk	Enc
12	Gewerbe Museum, Basel	Linen embroidery 1897/216 b.	Silk	1st 16t
13 a 2)	Gewerbe Museum, Basel	Embroide strips of vestment 1967/st. 57 a	Silk	abc
b		1967/st. 57 b	Silk	abc
14	Gewerbe Museum, Basel	Linen embroidery 1967/51 chasuble	Silk	16t
15	Gewerbe Museum, Basel	Linen embroidery 1967/st. 54 chasuble	Silk	14t
16	Gewerbe Museum, Basel	Embroidery cushion-cover	Silk	Enc
17	Gewerbe Museum, Basel	Embroidery cushion-cover 1967/st. 42	Silk	16t 17t
18	Gewerbe Museum, Basel	Embroidery 1967/st. 40	Silk	end
19	Gewerbe Museum, Basel	Embroidery 1967/st. 36	Silk	16t
20	Gewerbe Museum, Basel	Embroidery 1967/st. 33	Silk	16t
21	Gewerbe Museum, Basel	Damask 1923/8	Silk	16t
22	Gewerbe Museum, Basel	Silk velvet pile/1966/31	Silk	146
23	Gewerbe Museum, Basel	Damask 1926/26	Silk	16/

	Material	Date	Origin	Result
hes	Silk	about 1600	Italy?	Kermes
hes	Silk	16th. century	Switzerland	Cochineal
	Silk	End of the 16th. century	Italy	Brazil
	Silk	13/14th. century	Italy	Madder + Brazil?
	Silk	16/17th. century	Switzerland	Cochineal
7/st37	Silk	End of the 16th. century	Italy	Cochineal
	Silk	1st. half of the 16th. century	Italy	Kermes
57 a	Silk	about 1560	Italy	Cochineal
57	Silk	about 1560	Italy	Cochineal
	Silk	16th. century	Italy or France	Cochineal
	Silk	14th. century	Central Europe	Kermes
	Silk	End of the 16th. century	Italy	Cochineal
t. 42	Silk	16th./begin 17th. century	Italy	Cochineal+ Kermes
40	Silk	end 16th. century	Italy	Cochineal
36	Silk	16th. century	Italy	Sapan-wood
33	Silk	16th. century	Italy	Polish Cochineal+ a trace kermes
	Silk	16th. century	Italy	Polish Cochineal+ a trace kermes
	Silk	1460?	Central Europe	Cochineal
	Silk	16/17th. century	Italy	Polish Cochineal+ Kermes

Sample number	Collection	Description of the object	Material	Date
4	Gewerbe Museum, Basel	Embroidery 1967/st. 47	Silk	2nd half 16th. centur
5 a b	Gewerbe Museum, Basel	Embroidery 1967/st. 50	Silk	14/15th. cer
			Silk	14/15th. cer
6	Gewerbe Museum, Basel	Silk damask 1966/7	Silk	16th. centur
7	Gewerbe Museum, Basel	Velvet 1966/33a-c	Silk	about 1500
8	Gewerbe Museum, Basel	Brocade 1933/84	Silk	13/14th. cer
9	Gewerbe Museum, Basel	Weave 1933/96c	Silk	14th. centur
0	Gewerbe Museum, Basel	Florentine string 1933/59	Silk	end 15th. ce
1	Gewerbe Museum, Basel	Brocade 4 colouring 1933/95	Silk	14/15th. cer
2	Gewerbe Museum, Basel	Brocade 4 colouring 1933/92	Silk	14th. centur
3	Gewerbe Museum, Basel	Weave 1933/91	Silk	14/15th. cer
4	Gewerbe Museum, Basel	Halfsilk weave 1933/86	Silk	13/14th. cer
5	Gewerbe Museum, Basel	Brocade 1933/94	Silk	about 1400
6	Gewerbe Museum, Basel	Half silk 1933/99 f,g,l	Silk	14/15th. cer
7	Gewerbe Museum, Basel	Half silk brocade 1933/85	Silk	12/13th. cer
8	Gewerbe Museum, Basel	Half silk 1933/99a-d	Silk	14/15th. cer
9	Gewerbe Museum, Basel	Half silk 1933/98a	Silk	14/15th. cer
0 a b	Gewerbe Museum, Basel	Half silk 1933/97a	Silk	14th. centur
		Half silk 1933/97b	Silk	14th. centur
1	Gewerbe Museum, Basel	Brocade 1933/90	Silk	13th. centur
2	Gewerbe Museum, Basel	Half silk 1933/98	Silk	13/14th. cer
3	Gewerbe Museum, Basel	Half silk weave 1933/87	Silk	13/14th. cer
4	Gewerbe Museum, Basel	Weave 1933/83a,b	Silk	11/12th. cer
5	Gewerbe Museum, Basel	Damask 1929/28	Silk	end 16th. ce
6	Gewerbe Museum, Basel	Florentine board 1933/100	Silk	1st. half 16

	Material	Date	Origin	Result
7	Silk	2nd half 16th. century	Germany	Polish cochineal
0	Silk	14/15th. century	Germany	Madder
	Silk	14/15th. century	Germany	Madder + Brazil
	Silk	16th. century ?	Italy	Polish cochineal
	Silk	about 1500	Italy	Kermes
	Silk	13/14th. century	Italy	Red Wood
	Silk	14th. century?	Italy	Kermes
	Silk	end 15th. century	Italy	Kermes
	Silk	14/15th. century	Italy	Brazil
	Silk	14th. century	Italy	Brazil
	Silk	14/15th. century	Italy	not to indentify
86	Silk	13/14th. century	Germany	no sample enough
	Silk	about 1400	Italy	Brazil
.g.1	Silk	14/15th. century	Germany	Brazil
33/85	Silk	12/13th. century	Italy	Brazil
	Silk	14/15th. century	Germany	Brazil
	Silk	14/15th. century	Germany	Brazil
	Silk	14th. century	Germany	not to indentify
	Silk	14th. century	Germany	Brazil
	Silk	13th. century	Italy	not to indentify
	Silk	13/14th. century	Germany	Brazil
3/87	Silk	13/14th. century	Germany	Brazil
	Silk	11/12th. century?	Italy	Brazil
	Silk	end 16th. century	Italy	Cochineal
33/100	Silk	1st. half 16th. century	Italy	not to indentify

Sample number	Collection	Description of the object	Material	Date
47	Gewerbe Museum, Basel	Damask 1907/106	Silk	2nd. h
48	Gewerbe Museum, Basel	Brocade 1907/97	Silk	2nd. h
49	Gewerbe Museum, Basel	Weave 1907/96	Silk	14th.
50	Gewerbe Museum, Basel	Velvet brocade 1907/208	Silk	15th.
51	Gewerbe Museum, Basel	Velvet 1907/230	Silk	16/17t
52	Abegg Stiftung	Weave	Silk	end 15 century
53 a	Abegg Stiftung		Wool	16th.
b			Wool	16th.
54 a	Abegg Stiftung	Hanging	Wool	1525-1
b		Hanging	Wool	1525-1
c		Hanging	Wool	1525-1
55 a	Abegg Stiftung	"Borte" Cologne	Silk	middle 15th. c
b		"Borte" Cologne	Silk	middle 15th. c
56	Abegg Stiftung	Emroidery	Silk	middle 16th. c
57	Abegg Stiftung	Weave	Silk	about
58	Abegg Stiftung	Velvet chasuble	Silk	late 15
59	Abegg Stiftung	Velvet	Silk	late 16
60 a	Abegg Stiftung	Wool weave	Wool	middle
b		Wool weave	Wool	middle
61	Abegg Stiftung	Velvet Bern, Historisches museum	Silk	2nd. h
62 a	Kunigl. Livrustkammaren	Velvet from shield 2611a	Silk	1548
b		Velvet from shield	Silk	1548

	Material	Date	Origin	Result
8	Silk	2nd. half 16th. century	Italy	Polish Cochineal
	Silk	2nd. half 15th. century	Italy	Polish Cochineal+ Kermes
	Silk	14th. century	Italy	not to identify
	Silk	15th. century	Italy	Polish Cochineal+ Kermes
	Silk	16/17th. century?	?	Cochineal+ Kermes
	Silk	end 15th. begin 16th. century	Spain	Kermes + a trace Madder
	Wool	16th. century	Switzerland	Madder
	Wool	16th. century	Switzerland	Madder
	Wool	1525-1550	Belgium Oudenaarde	Madder
	Wool	1525-1550	Belgium Oudenaarde	Madder+ Brazil
	Wool	1525-1550	Belgium Oudenaarde	no sample enough
	Silk	middle of the 15th. century	Germany Cologne	Madder
	Silk	middle of the 15th. century	Germany Cologne	Madder
	Silk	middle of the 16th. century	Italy	Brazil
	Silk	about 1500	Spain	Kermes
	Silk	late 15th. century	Italy or Spain	Polish Cochineal
	Silk	late 16th. century	Italy	Cochineal
	Wool	middle 16th. century	Peru (Inka)	Cochineal
	Wool	middle 16th. century	Peru (Inka)	Cochineal
	Silk	2nd. half 15th. century	Italy	Kermes = Lac-dye
611a	Silk	1548	Poland? Augsburg?	Polish Cochineal
	Silk	1548	Poland? Augsburg?	Polish Cochineal+ a trace kermes

Sample number	Collection	Description of the object	Material	Date
63	Kungl. Livrustkammaren	Velvet from elegant harness-saddle of Erik XIV 2930	Silk	1560
64	Kungl. Livrustkammaren	Velvet from inside of shield Italian manufacture, 3936	Silk	late
65 a	Kungl. Livrustkammaren	Silk from embroidery for canopy of the wife of	Silk	about
b		Erik XIV 06/6687	Silk	about
66	Kungl. Livrustkammaren	Polish trumpet-flag 755	Silk	about
67	Erzbischöfliches Diozesan-museum	Embroidery 424, S 90	Silk	2nd. 15th
68	Erzbischöfliches Diozesan-museum	Embroidery 416, S 89	Silk	2nd. 15th
69	Erzbischöfliches Diozesan-museum	Embroidery 413-414, S 89	Silk	2nd. 15th
70	Erzbischöfliches Diozesan-museum	Weave + embroidery 373, S 80	Silk	2nd. 15th
71	Erzbischöfliches Diozesan-museum	Weave + embroidery 365, S 79	Silk	15th
72 a	Erzbischöfliches Diozesan-museum	Velvet 305 S 71, Abb. 74	Wool	1st. 16th.
b		Velvet	Wool	1st. 16th.
73 a	Schweizerisches Landesmuseum, Zürich	Wool weave IN 6954	Wool	about
b		Wool weave	Wool	about
c		Wool weave	Wool	about
d		Wool weave	Wool	about
e		Wool weave	Wool	about
f		Wool weave	Wool	about
g		Wool weave	Wool	about

Object	Material	Date	Origin	Result
1 elegant idle of 130	Silk	1560-1562	Belgium Antwerp	Polish Cochineal
1 inside of ian manufac-	Silk	late 16th. century	Italy Milan	Polish Cochineal
embroidery of the wife	Silk	about 1568	Sweden Stockholm	Polish Cochineal Brazil
/6687	Silk	about 1568	Sweden Stockholm	Polish Cochineal
pet-flag 755	Silk	about 1605	Poland	Polish Cochineal
424, S 90	Silk	2nd. half of the 15th. century	Germany Cologne	Madder
416, S 89	Silk	2nd. half of the 15th. century	Germany Cologne	Madder
413 414, S 89	Silk	2nd. half of the 15th. century	Nieder-Rhein	Madder trace B
roidery	Silk	2nd. half of the 15th. century	Germany Cologne	Madder
roidery	Silk	15th. century	Germany Cologne	Madder
S 71, Abb. 74	Wool	1st. half of the 16th. century	Germany Cologne	Madder
	Wool	1st. half of the 16th. century	Germany Cologne	Madder
IN 6954	Wool	about 1470	Basel or Oberrhein	Madder
	Wool	about 1470	Basel or Oberrhein	not to identif
	Wool	about 1470	Basel or Oberrhein	Madder
	Wool	about 1470	Basel or Oberrhein	Madder
	Wool	about 1470	Basel or Oberrhein	Madder
	Wool	about 1470	Basel or Oberrhein	Madder
	Wool	about 1470	Basel or Oberrhein	not to identif

Sample number	Collection	Description of the object	Material	Date
74 a	Schweizerisches Landesmuseum, Zürich	Wool weave LM 7375	Wool	en
b		Wool weave	Wool	en
c		Wool weave	Wool	en
d		Wool weave	Wool	en
e		Wool weave	Wool	en
75 a	Schweizerisches Landesmuseum, Zürich	Wool embroidery LM 1384	Wool	159
b		Wool embroidery	Wool	159
76 a	Schweizerisches Landesmuseum, Zürich	Wool weave LM 200 21	Wool	abc
b		Wool weave	Wool	abc
c		Wool weave	Wool	abc
d		Wool weave	Wool	abc
e		Wool weave	Wool	abc
f		Wool weave	Wool	abc
g		Wool weave	Wool	abc
77 a	Schweizerisches Landesmuseum, Zürich	Wool embroidery LM 16659	Wool	158
b		Wool embroidery	Wool	158
c		Wool embroidery	Wool	158
78 a	Schweizerisches Landesmuseum, Zürich	Wool embroidery LM 5496	Wool	151
b		Wool embroidery	Wool	151
79 a	Schweizerisches Landesmuseum, Zürich	Wool weave LM 1959	Wool	abou
b		Wool weave	Wool	abou

	Material	Date	Origin	Result
34	Wool	end of the 15th. century	Switzerland	Sapan? wood?
	Wool	end of the 15th. century	Switzerland	Madder
	Wool	end of the 15th. century	Switzerland	Madder
	Wool	end of the 15th. century	Switzerland	Madder
	Wool	end of the 15th. century	Switzerland	Madder
	Wool	1593	Switzerland	not to identify
	Wool	1593	Switzerland	not to identify
	Wool	about 1600	Switzerland Kanton Luzern	Red sandel- wood
	Wool	about 1600	Switzerland Kanton Luzern	Brazil
	Wool	about 1600	Switzerland Kanton Luzern	Brazil
	Wool	about 1600	Switzerland Kanton Luzern	Brazil
	Wool	about 1600	Switzerland Kanton Luzern	not to identify
	Wool	about 1600	Switzerland Kanton Luzern	Madder + Brazil
	Wool	about 1600	Switzerland Kanton Luzern	Brazil
659	Wool	1580	Switzerland Schaffhausen	Madder
	Wool	1580	Switzerland Schaffhausen	not to identify
	Wool	1580	Switzerland Schaffhausen	Brazil
	Wool	1519	East Switzerland Kanton Thurgau	Madder
	Wool	1519	East Switzerland Kanton Thurgau	Madder
	Wool	about 1480	Switzerland	Madder
	Wool	about 1480	Switzerland	Madder

Sample number	Collection	Description of the object	Material	Date
80 a	Schweizerisches Landesmuseum, Zürich	Wool embroidery LM 4696	Wool	1568
b		Wool embroidery	Wool	1568
81 a	Schweizerisches Landesmuseum, Zürich	Wool weave LM 29359	Wool	1566
b		Wool weave	Wool	1566
c		Wool weave	Wool	1566
82 a	Schweizerisches Landesmuseum, Zürich	Wool embroidery LM 21966	Wool	about
b		Wool embroidery	Wool	about
83 a	Schweizerisches Landesmuseum, Zürich	Wool embroidery LM 24487	Wool	about
b		Wool embroidery	Wool	about
c		Wool embroidery	Wool	about
d		Wool embroidery	Wool	about
84 a		Wool embroidery LM 6096	Wool	1552
b	Schweizerisches Landesmuseum, Zürich	Wool embroidery	Wool	1552
c		Wool embroidery	Wool	1552
d		Wool embroidery	Wool	1552
85	Schweizerisches Landesmuseum, Zürich	Wool embroidery LM 6097	Wool	1533
86	Gewebesammlung, Krefeld	Brocade 01310	Silk	about
87	An der Ingenieurschule für Textilwesen	Damask 01982 A	Silk	16th.
88	An der Ingenieurschule für Textilwesen	Weave 02983	Silk	Begin
89	An der Ingenieurschule für Textilwesen	Brocade 01151	Silk	Middl 15th.

	Material	Date	Origin	Result
4696	Wool	1568	Switzerland	Madder
	Wool	1568	Switzerland	Madder
	Wool	1566	Basel or Oberrhein	Madder + Cochineal
	Wool	1566	Basel or Oberrhein	Madder
	Wool	1566	Basel or Oberrhein	Madder
21966	Wool	about 1530/40	Switzerland Kanton Glarus	Madder
	Wool	about 1530/40	Kanton Glarus	Madder
24487	Wool	about 1560	Switzerland Innenschweiz	till now not to identify
	Wool	about 1560	Switzerland Innenschweiz	Madder
	Wool	about 1560	Switzerland Innenschweiz	Madder
	Wool	about 1560	Switzerland Innenschweiz	Madder
6096	Wool	1552	Switzerland Kanton Luzern	Madder
	Wool	1552	Switzerland Kanton Luzern	Kermes + Cochineal
	Wool	1552	Switzerland Kanton Luzern	Madder + not to identify 'spot'
	Wool	1552	Switzerland Kanton Luzern	Madder + not to identify 'spot'
	Wool	1533	Switzerland Schaffhausen	not to identify
	Silk	about 1600	Spain	Cochineal
	Silk	16th. century	Italy	Cochineal
	Silk	Begin 16th. century	Italy or Spain	Madder
	Silk	Middle of the 15th. century	Italy	Kermes

Sample number	Collection	Description of the object	Material	I
90	An der Ingenieurschule für Textilwesen	Velvet 00059	Silk	1
91	An der Ingenieurschule für Textilwesen	Weave 01270	Silk	8
92	An der Ingenieurschule für Textilwesen	Brocade "Borte" 01133 A,B	Silk	2 1
93	An der Ingenieurschule für Textilwesen	Brocade 01156	Silk	2 1
94	An der Ingenieurschule für Textilwesen	Brocade 01159	Silk	2 1
95	An der Ingenieurschule für Textilwesen	Velvet brocade 00185	Silk	1
96	Osterreichisches Museum für Angewandte Kunst, Wien	Velvet T 2320	Silk	2 1
97	Osterreichisches Museum für Angewandte Kunst, Wien	"Kölner-Borte" T 952	Silk	1
98	Osterreichisches Museum für Angewandte Kunst, Wien	Velvet brocade T 9236	Silk	2 1
99	Osterreichisches Museum für Angewandte Kunst, Wien	Weave T 869	Silk	2 1
100	Osterreichisches Museum für Angewandte Kunst, Wien	Velvet T 4572	Silk	1
101	Osterreichisches Museum für Angewandte Kunst, Wien	Brocade + velvet T 922	Silk	1
102	Osterreichisches Museum für Angewandte Kunst, Wien	Brocade + velvet T 5597	Silk	1
103	Osterreichisches Museum für Angewandte Kunst, Wien	Silk brocade T 4128	Silk	2
104 a	Staatliche Museen Preussischer Kulturbesitz Kunstgewebe Museum, Berlin	Altar Antependium 16,25	Wool	2 1
b			Wool	2 1
c			Wool	2 1
d			Wool	2 1

	Material	Date	Origin	Result
	Silk	15th. century	Italy	Kermes
	Silk	about 1500	Spain	Kermes
1133 A,B	Silk	2nd. half of the 15th. century	Germany Cologne	Madder
	Silk	2nd. half of the 15th. century	Italy Florence	Kermes
	Silk	2nd. half of the 15th. century	Italy Florence	Madder + Brazil?
185	Silk	15th. century	Italy	Kermes
	Silk	2nd. half of the 16th. century	Italy or Spain	Cochineal
952	Silk	1497	Germany Cologne	Madder + not to identify 'spot'
92	Silk	2nd. half of the 15th. century	Italy	Cochineal
	Silk	2nd. half of the 15th. century	Spain Granada	Madder + Kermes
	Silk	1425-1450	Italy	Madder + Brazil
T 922	Silk	Middle 15th. century	Italy	Polish cochineal
T 5597	Silk	Begin 16th. century	Italy	Cochineal
28	Silk	about 1550	Spain	Cochineal
16,25	Wool	2nd. half of the 15th. century	Basel	not to identify
	Wool	2nd. half of the 15th. century	Basel	Madder
	Wool	2nd. half of the 15th. century	Basel	Madder
	Wool	2nd. half of the 15th. century	Basel	not to identify

Sample number	Collection	Description of the object	Material
105	Staatliche Museen Preussischer Kulturbesitz Kunstgewebe Museum, Berlin	Velvet 1986, 10	Silk
106 a	Staatliche Museen Preussischer Kulturbesitz Kunstgewebe Museum, Berlin	Embroidery/Satin 65, 10	Silk
b		Satin + embroidery 65, 10	Silk
107 a	Staatliche Museen Preussischer Kulturbesitz Kunstgewebe Museum, Berlin	Embroidery 65,33	Silk
b		Embroidery	Silk
108	Staatliche Museen Preussischer Kulturbesitz Kunstgewebe Museum, Berlin	Embroidery chasuble 63,6	Silk
109	Staatliche Museen Preussischer Kulturbesitz Kunstgewebe Museum, Berlin	Velvet 62, 155	Silk
110	Riksanrik-varieämbetet, Stockholm	Piece of red velvet from chasuble	Silk
111	Riksanrik-varieämbetet, Stockholm	Piece of red velvet from chasuble	Silk
112	Riksanrik-varieämbetet, Stockholm	Piece of brownish silk from Danish flag	Silk
113	Museum Narodowe Warszawie, Poland	Velvet textile from Italy	Silk
114 a	Museum Narodowe Warszawie, Poland	Brocade-With the pattern of granate	Silk
b			Silk
115	Museum Narodowe Warszawie, Poland	Velvet. Fragment of a chasuble with the pattern of granate	Silk
116 a	Musée Historique des Tissue	Velvet 22864	Silk
b			Silk
117	Musée Historique des Tissue	Velvet 33.357	Silk
118	Musée Historique des Tissue	Velvet 30.935	Silk

	Material	Date	Origin	Result
	Silk	1480	Italy or Spain	Polish Cochineal
5, 10	Silk	1550	France	Cochineal+ Brazil
65, 10	Silk	1550	France	Brazil
	Silk	about 1600	Portugal	Madder + Cochineal
	Silk	about 1600	Portugal	Madder + Cochineal
e 63,6	Silk	1588	Spain	Brazil
	Silk	Middle 15th. century	Italy	Polish Cochineal
t from	Silk	end of the 15th. century	Italy	Kermes
t from	Silk	1st. half of the 17th. century	Italy?	Cochineal
silk	Silk	1634	Danmark	Brazil
m Italy	Silk	early 16th. century	Italy	Cochineal
attern	Silk	16th. century	Turkey	Cochineal
	Silk	16th. century	Turkey	Cochineal
f a pattern	Silk	15th. - 16th. century	Italy	Cochineal?
	Silk	end of the 15th. begin of the 16th. century	Italy	Polish Cochineal
	Silk	end of the 15th. or begin of the 16th. century	Italy	Polish Cochineal
	Silk	2nd. half of the 15th. century	Italy	Polish Cochineal
	Silk	2nd. half of the 15th. century	Italy	Polish Cochineal

Sample number	Collection	Description of the object	Material	Date
119 a	Kunstindustri-museet, Oslo	Norwegian tapestry, "Loth and his daughters fleeing from Sodom"	Wool	End
b			Wool	End
120 a	Kunstindustri-museet, Oslo	Tapestry. Horsemen and Knights in armour	Wool	about
b			Wool	about
c			Wool	about
d			Wool	about
e			Wool	about
121	Museum Narodowe Warszawie, Poland	Dated by the coat of arm of Sforza and the white Eagle of our king Sigismundus the First to the first half of the century	Silk	1st. 16th
122	Museum Narodowe Warszawie, Poland	Textile from Italy	Silk	1650
123	The Metropolitan Museum of Art, New York	Satin, with gold and silver, 52.20.21	Silk	16th
124	The Metropolitan Museum of Art, New York	Medallions a fal corner, servant in a velvet on twill ground, 52.20.11	Silk	Tahn
125	The Metropolitan Museum of Art, New York	Pile on pile satin velvet 46.156.140	Silk	Late
126	Mussés Royaux d'Art et d'Histoire, Brussels	Tapestry	Wool	3rd. 16th
127 a	Mussés Royaux d'Art et d'Histoire, Brussels	Tapestry	Wool	middle
b		Tapestry	Wool	middle
128 a	Mussés Royaux d'Art et d'Histoire, Brussels	Tapestry	Wool	3rd. 15th
b		Tapestry	Wool	3rd. 15th
c		Tapestry	Wool	3rd. 15th
129	Aartsbisschoppelijk Museum, Utrecht	Velvet 880	Silk	last 15th

	Material	Date	Origin	Result
y, "Loth fleeing	Wool	End of 16th. century	Norwegian	Kermes
	Wool	End of 16th. century	Norwegian	Madder
and	Wool	about 1550	Belgium, Brussel	Madder
	Wool	about 1550	Belgium, Brussel	Cochineal
	Wool	about 1550	Belgium, Brussel	Madder
	Wool	about 1550	Belgium, Brussel	Madder
	Wool	about 1550	Belgium, Brussel	not to identify
of arm of ite Eagle mundus the st half	Silk	1st. half of the 16th. century	Italy	Kermes + Cochineal
y	Silk	1650	Italy	Cochineal+ Kermes
and	Silk	16th. century	Asia Minor	Cochineal+ Kermes
corner, ret on .20.11	Silk	Tahnas period	Shah of Persia	Cochineal+ Kermes
in velvet	Silk	Late 15th. century	Italy	Cochineal+ Kermes
	Wool	3rd. quarter of 16th. century	Belgium, Oudenaard	Madder
	Wool	middle 16th. century	Belgium, Brussel	Madder
	Wool	middle 16th. century	Belgium, Brussel	Madder
	Wool	3rd. quarter of 15th. century	Belgium, Tournai	Madder
	Wool	3rd. quarter of 15th. century	Belgium, Tournai	Madder
	Wool	3rd. quarter of 15th. century	Belgium, Tournai	Madder
	Silk	last quarter of 15th. century	Italy	Kermes

Sample number	Collection	Description of the object	Material
130	Aartsbischoppelijk Museum, Utrecht	Damask 910	Silk
131	Aartsbischoppelijk Museum, Utrecht	Velvet. Cope of David of Burgundy	Silk
132	Deutsches Tapeten-Museum, Kassel	Wall hanging	Silk
133 a	Ufizi Galleria	Tapestry	Silk
b		Tapestry	Wool
c		Tapestry	Wool
d		Tapestry	Wool
134	Muzej za Umjet nost i Obrt Zagreb	Renascence tapestry	Wool
135	Museos de Arte-Museo Textil, Barcelona	no. 23.758	Silk
136	Museos de Arte-Museo Textil, Barcelona	no. 22.213	Silk
137	Museos de Arte-Museo Textil, Barcelona	no. 23.878	Silk
138	Museos de Arte-Museo Textil, Barcelona	no. 22.690	Silk
139 a	Museos de Arte-Museo Textil, Barcelona	no. 32.946	Silk
b		no. 32.946	Silk
140	Museos de Arte-Museo Textil, Barcelona	no. 23.769	Silk
141	Museos de Arte-Museo Textil, Barcelona	no. 32.951	Silk
142	Instituto de José de Figueiredo, Lisabon	Tapestry "Birth of Christ" Museu Nacional de Arte Antiga Inv. no. 28	Wool
143 a	Instituto de José de Figueiredo, Lisabon	Tapestry: History of Hercules Museu Nacional de Arte Antiga Inv. no. 73	Wool
b			Wool

	Material	Date	Origin	Result
d	Silk	1525 - 1550	Italy	Cochineal?
	Silk	for 1450	Italy	Kermes
	Silk	1550/1570	Italy	Cochineal
	Silk	3rd. quarter of 16th. century	Flemish, Brussel?	Cochineal
	Wool	3rd. quarter of 16th. century	Flemish, Brussel?	Madder + Brazil
	Wool	3rd. quarter of 16th. century	Flemish, Brussel?	Kermes
	Wool	3rd. quarter of 16th. century	Flemish. Brussel?	not to identify
	Wool	16th. century	Belgium, Brussel	Madder
	Silk	16th.-17th. century		Cochineal
	Silk	16th. century		Kermes
	Silk	15th. century		Kermes
	Silk	15th. century	Spain	Cochineal?+ a trace Brazil
	Silk	14th. century		Kermes
	Silk	14th. century		Kermes
	Silk	16th. century		Cochineal
	Silk	17th. century		Kermes
Christ" rte	Wool	Begin 16th. century	Belgium, Brussel	Madder
f onal no. 73	Wool	Middle of 16th. century	Belgium Brussel	Madder
	Wool	Middle of 16th. century	Belgium Brussel	Madder

	Material	Date	Origin	Result
surprend useu de Combra	Wool	Middle of 16th. century	Belgium, Bruges	not to identify
de rcal	Wool	2nd half of the 16th. century	Belgium, Brussel	Madder
	Wool	2nd. half of the 16th. century	Belgium, Brussel	Madder
ibérant Tavares telo-	Wool	End of 16th. century	Belgium, Brussel	Madder + Brazil
ead. Museu antiga.	Wool	17th. century	Indo-Portugaise	Madder
alien" lure	Silk	15th. century	Italy	Polish Cochineal
Vila	Silk	15th. century	Italy	Cochineal
e ia cu	Silk	15th. century		Polish Cochineal
Velours.	Silk	15th. century		Polish Cochineal
	Silk	15th. century		Kermes
u Antiga	Silk	15th. century	Spain	Polish Cochineal
ien	Silk	End of 15th. or begin 16th. century	Italy	Polish Cochineal
	Silk	End of 15th. century	Indo-Portugaise	Madder
ars.	Silk	16th. century		Cochineal
eu	Silk	16th. century	Brussa	Cochineal
745 e Arte	Silk	Middle of 17th. century	Chine	Cochineal
	Silk	17th. century	India	Cochineal

Sample number	Collection	Description of the object	Material
144	Instituto de José de Figueiredo, Lisabon	Tapestry: Vulcain surprend Vénus avec Marte-Museu de Machado de Castro Combra	Wool
145 a	Instituto de José de Figueiredo, Lisabon	Tapestry: Bataille de Pharsale.Sé Patriarcal de Lisabon	Wool
b			Wool
146	Instituto de José de Figueiredo, Lisabon	Tapestry: Cyrus libérant les Hébreux.Museu Tavares Proença Júnior Castelo-Branco	Wool
147	Instituto de José de Figueiredo, Lisabon	Embroidery bed-spread.Museu Nacional de Arte Antiga. Inv. no. 113	Wool
148 a	Instituto de José de Figueiredo, Lisabon	Weave: "Velours italien" et soi de la doublure	Silk
b		Velvet: Palácio de Vila Viçosa	Silk
149	Instituto de José de Figueiredo, Lisabon	Weave: Doublure de la Chape . Sé de Viscu	Silk
150 a	Instituto de José de Figueiredo, Lisabon	Thread: Chape du parement Anglais-Velours. Sé de Portalegre	Silk
b			Silk
151	Instituto de José de Figueiredo, Lisabon	Velvet: 1616 Museu Nacional de Arte Antiga	Silk
152	Instituto de José de Figueiredo, Lisabon	2033 Velours Italien	Silk
153	Instituto de José de Figueiredo, Lisabon	3413 Embroidery	Silk
154	Instituto de José de Figueiredo, Lisabon	Parement de velours. Museu de Aveiro	Silk
155	Instituto de José de Figueiredo, Lisabon	Velours Turc Museu Gulbenkian	Silk
156	Instituto de José de Figueiredo, Lisabon	Bed-spread no. 1745 Museu Nacional de Arte Antiga	Silk
157	Instituto de José de Figueiredo, Lisabon	Bed-spread 2136	Silk

Sample number	Collection	Description of the object	Material	D
158 a	Instituto de José de Figueiredo, Lisabon	Weave.Igreja de Aldeia Galega	Cotton	1
b		Weave	Cotton	1
c		Weave	Cotton	1
159	Instituto de José de Figueiredo, Lisabon	Embroidery bed-spread 2232	Cotton	1
160 a	ABEGG Stiftung, Bern	Brocade	Silk	1
b		Velvet	Silk	1
c			Silk	1
161	Soprintendenza Alle Gallerie Florence	Brocade	Silk	1
162	Soprintendenza Alle Gallerie Florence	Brocade	Silk	1
163	Soprintendenza Alle Gallerie Florence	Satin Broccatello	Silk	a
164	Soprintendenza Alle Gallerie Florence	Satin	Silk	1
165	Soprintendenza Alle Gallerie Florence	Velvet	Silk	1
166	Soprintendenza Alle Gallerie Florence	Velvet	Silk	a
167	Soprintendenza Alle Gallerie Florence	Velvet	Silk	1
168	Soprintendenza Alle Gallerie Firenze	Velvet	Silk	
169	Soprintendenza Alle Gallerie Firenze	Velvet	Silk	
170	Soprintendenza Alle Gallerie Florence	Satin	Silk	
171	Soprintendenza Alle Gallerie Florence	Satin	Silk	
172	Soprintendenza Alle Gallerie Florence	Satin	Silk	
173	Soprintendenza Alle Gallerie Florence	Satin	Silk	
174	Soprintendenza Alle Gallerie Florence	Brocade	Silk	

	Material	Date	Origin	Result
Aldeia	Cotton	16th. century	Indien	Madder
	Cotton	16th. century		Madder
	Cotton	16th. century		Madder
pread	Cotton	18th. century	Indien	Madder
	Silk	1417 - 1463	Italy	Sumach
	Silk	1417 - 1463	Italy	Sumach
	Silk	1417 - 1463	Italy	Sumach
	Silk	16th. century	Italy, Toscana	Polish Cochineal+ a trace Ker
	Silk	16th. century	Italy, Lucchese	Polish Cochineal+ a trace Ker
o	Silk	about 1550	Italy, Lucchesa	Polish Cochineal+ a trace Ker
	Silk	16th. century	Italy, Lucchesa	Polish Cochineal
	Silk	16th. century	Italy, Toscana	Kermes
	Silk	about 1550	Italy, Toscana	Polish Cochineal
	Silk	16th. century	Florence	Cochineal+ a trace Ker
	Silk	1550 - 1600	Italy, Toscana	Kermes
	Silk	17th. century	Italy, Toscana	Cochineal
	Silk	17th. century	Italy, Lucchesa	Cochineal
	Silk	17th. century	Italy, Toscana	Brazil
	Silk	17th. century	Italy, Florence	Cochineal
	Silk	17th. century	Italy, Toscana	Cochineal
	Silk	about 1650	Italy, Toscana	Cochineal

Sample number	Collection	Description of the object	Material	
175	Soprintendenza Alle Gallerie Florence	Satin	Silk	1
176	Soprintendenza Alle Gallerie Florence	Satin	Silk	
177	Soprintendenza Alle Gallerie Florence	Weave	Silk	2
178	Soprintendenza Alle Gallerie Florence	Brocade	Silk	
179	Soprintendenza Alle Gallerie Florence		Silk	
180	Soprintendenza Alle Gallerie Florence	Brocade	Silk	
181	Soprintendenza Alle Gallerie Florence	Brocade	Silk	
182	Rijksmuseum, Amsterdam	Fragment of the Hercules tapestry 1725 1B	Wool	
183	Rijksmuseum, Amsterdam	Tapestry RBK 1725 1A	Wool	
184	Rijksmuseum, Amsterdam	Tapestry	Wool	
		Tapestry	Wool	
185	Rijksmuseum, Amsterdam	Tapestry	Wool	

NOTES:

- 1) The samples 1 to 5 belong to a different research programm.
- 2) When the sample contains more than one shade of red, they are divided into a.b.c. etc. where a is e.g. orange, b is violet-red etc.
- 3) Should read 'tapestry'

	Material	Date	Origin	Result
	Silk	17th. century	Italy, Toscana	Cochineal
	Silk	17th. century	Italy, Toscana	Orseille?
	Silk	about 1650	Italy, Toscana	Cochineal Brazil
	Silk	18th. century	Italy, Toscana	Cochineal Brazil
	Silk	17th. century	Italy, Toscana	Cochineal Brazil
	Silk	14-15th. century	Italy, Modena	Cochineal Brazil
	Silk	16th. century	Florence	Cochineal Brazil
the	Wool	1485 - 1500	France-Flemish	Madder
est. 1725 1B	Wool	1485 - 1500	France-Flemish	Madder
1725 1A	Wool	3rd. quarter 15th. century	South-Holland	Madder
	Wool	3rd. quarter 15th. century	South-Holland	Madder
	Wool	Begin 16th. century	France-Flemish	Redwood

sh programm.

red, they

mge, b is

5. Discussion of Results

To give an impression of the relations between the analyzed dyestuffs, the period 1450 - 1600 was divided into periods of 25 years.

The frequency of the occurrence of the different dyestuffs was placed in these periods when the samples were well-dated. If e.g. the 2nd half of the 16th Century or the middle of the 16th Century was mentioned as a date only, it is difficult to classify same. These samples then were classified in the third quarter of the 16th Century. The total number of the samples was counted and in each period, the percentage per dyestuff was calculated.

From statistical point of view this method is not quite correct, because the number of samples was unequal in the different periods. Thus from the third quarter of the 16th Century more samples were analyzed than from the 1st quarter of the 16th Century. Nevertheless the different diagrams give a pretty good picture of the occurrence of the different dyestuffs over the entire period. In this case it was not possible to calculate purely statistically, which value the chance of occurrence of a particular dyestuff would have. There are too many uncertain factors to calculate the chance correctly to improve this, the population considered should have been defined exactly with an instruction on account of which one can decide whether or not an element belongs to the population.

Moreover sample-material has to be obtained from the population aselectly. Anyhow it is highly questionable if in future researches improvement could be achieved in the above mentioned requirements, as e.g. the date of an object is mostly based on style-critical characteristics. Some degree of uncertainty always goes with this date anyway.

In spite of the imperfect statistical process, still a number of particular aspects from the research did arise.

5.1 The occurrence of Kermes

The use of Kermes indeed disappears very quickly after the import of Cochineal from America.

Herewith the data from the literature (3) are confirmed. By means of the data obtained from this research it is possible now to give an indication of the date of an object.

One could minimally state a date-limit of about 1500-1525 (fig. 1-4).

5.2 The occurrence of Redwood

Particularly striking is, that samples which were dated before 1450 (running from the 11th till 1450) about 80% of all samples contain Redwood. This is comparable with data from old recipe-books in this period. In certainly half of the recipes to dye red, Redwood (Brasilwood) occurs (15).

After 1450 suddenly the occurrence of Redwood disappears in the samples, whilst in the 3rd quarter of the 16th Century unexpectedly again Redwood is present in the samples, but after a short time the presence of Redwood decreases (fig 3). Our explanation of this phenomenon is based on a number of historical facts.

Redwood, and especially *Caesalpinia sappan* originates from the East Indies, Ceylon etc.. From these regions the Redwood was brought over the continent to Europe via the so called Silk-route over Constantinople.

In 1453 Constantinople was captured by the Turcos owing to this fact the old trade-route was concluded.

Hardly no Redwood was imported until the discovery of South America. On discovery of America the Spaniards found enormous forests with Redwood-trees (hence the name Brasil) and soon large quantities were imported. This Redwood, however, did have a rather bad light fastness and very soon the government did put an embargo on using Redwood on textile of a good quality. Owing to this the use of Redwood dropped. The embargos were often eluded, although rather heavy punishments were put on it (2.9).

5.3 Dividing to Country and Material

The samples that were analyzed, are distributed according to material and in all cases this was wool or silk.

Dyestuff of 80% of the wool samples was Madder, whilst in 84% of the silk samples Kermes, Polish Cochineal or Cochineal, all from scale insects, were analyzed (fig.13,14).

It is possible that these data may be based on the price of the different materials. Silk however is a very precious material and it should be logical to dye this with a good and expensive dyestuff. All dyestuffs from insects are much more precious than Madder. Dividing the analysis results according to Country of origin, hardly no Madder seems to occur in Italian samples (fig 5-8), whilst hardly no Kermes does occur in samples from Middle Europe (fig 9-13). Reasons for these phenomena are hardly to be rendered, was Italy more civilized in this time or was it closer to the Country of origin of Kermes?

In the literature on the weaving of carpets in the Netherlands very little was mentioned about dyeing of the yarns used. Mentioned however is, that e.g. woollen yarns were dyed in the place itself, whilst dyed silk yarns were imported (19).

5.4 Occurrence of Kermes and Polish Cochineal

During analysis it became clear that there were used more kinds of Kermes than known to the authors. *Coccus ilicis* L. and *Magarode polonicus* both kind of a coccus insect, were used as reference materials.

From the spot pattern on the thin layer plates it was obvious, that apart from the two kinds that have been mentioned above, positively more kinds of coccus insects must have been used, that apart from Kermes acid also contain other components but still do belong to the same group (fig. 16).

By studying dyeing literature of the 16th Century it was found out that in the Plictho from Rosetti (15) one positively pays attention to these different kinds. A clear quality difference was mentioned.

The following classification was given:

"So that you will understand that wanting to dye Silk, it be in your mind that Crimson is of major perfection according to the land.

For dyeing you will need more or less according to its goodness and therefore you need greater or lesser quantity for every pound. And that you will better understand, below you will distinguish according to what are the kinds of the Crimson and the Provinces where it is born. viz,

Crimson of the Marche

Crimson fine of the West

Crimson Slavic or Ragusian

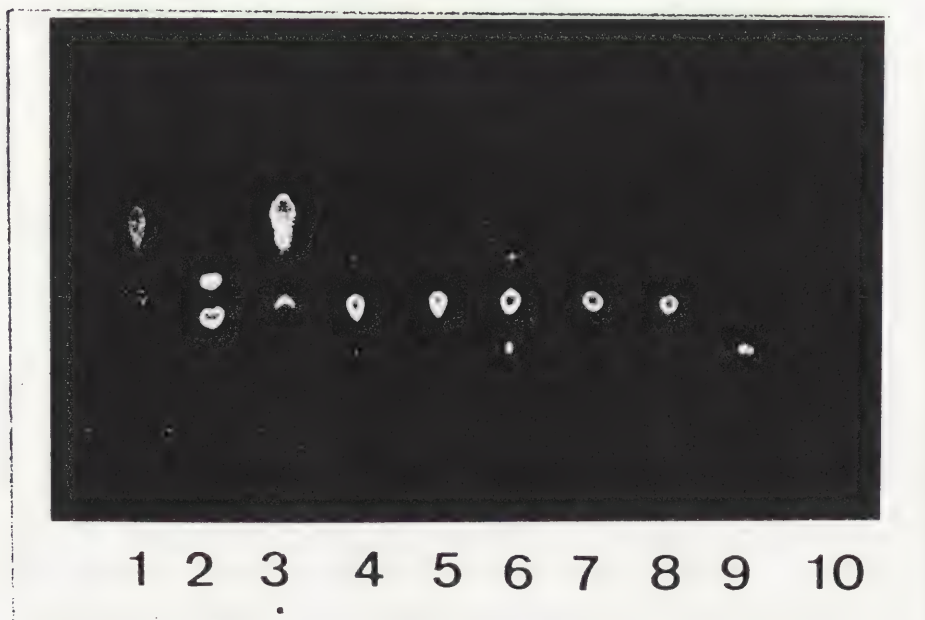
Crimson of the Levant

Crimson coarse of the West

Crimson coarse of the Levant"

Also in other recipes more than one kind of Kermes was mentioned (7.8). It should be useful to pay more attention to these Kermes-species and their identification in future research.

PHOTO 1



- | | |
|---------------------------------|---------------------------------|
| 1. Cochineal (reference) | 6. Sample 139a (Kermes) |
| 2. Kermes | 7. Sample 139b (Kermes) |
| 3. Polish Cochineal (reference) | 8. Sample 141 (Kermes) |
| 4. Sample 136 (Kermes) | 9. Kopp's Purpurine (reference) |
| 5. Sample 137 (Kermes) | 10. Sample 78b (Madder) |

6. Suggestions for a further Research

As a great number of textile samples has been analyzed it is now possible to identify organic red-dyestuffs with great certainty. Not only in textiles, but also polychromed sculptures, paintings and illuminated manuscripts.

To get similar experience with other organic dyestuffs, e.g. yellow dyestuffs, the authors wish to set up a comparative research for yellow dyestuffs in textile from the period 1500 - 1800.

PHOTO 2

- | | |
|----------------------------------|------------------------|
| 1. Cochineal (reference) | 6. Sample 81b (Madder) |
| 2. Sample 80a (Madder) | 7. Sample 81c (Madder) |
| 3. Sample 80b (Madder) | 8. Sample 82a (Madder) |
| 4. Sample 81a (Madder+Cochineal) | 9. Sample 82b (Madder) |
| 5. Madder (reference) | 10. Kermes (reference) |

PHOTO 3

- | | |
|--------------------------|-----------------------------|
| 1. Cochineal (reference) | 6. Sample 9 (Madder+Brazil) |
| 2. Sample 6 (Kermes) | 7. Sample 10 (Cochineal) |
| 3. Sample 7 (Cochineal) | 8. Sample 11 (Cochineal) |
| 4. Sample 8 (Brazil) | 9. Sample 12 (Kermes) |
| 5. Madder (reference) | 10. Kermes (reference) |

PHOTO 2



PHOTO 3

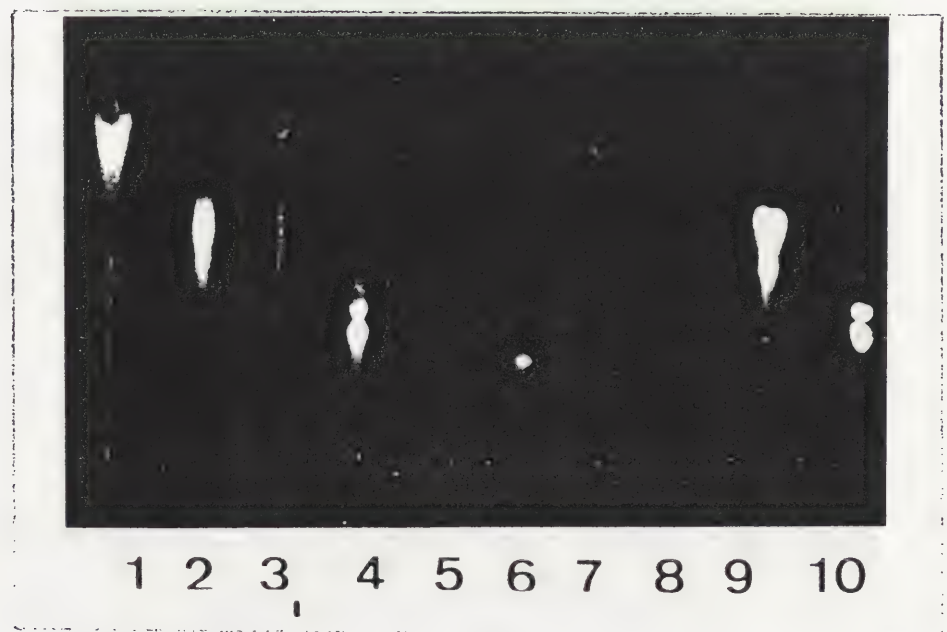


Fig. 1. ...

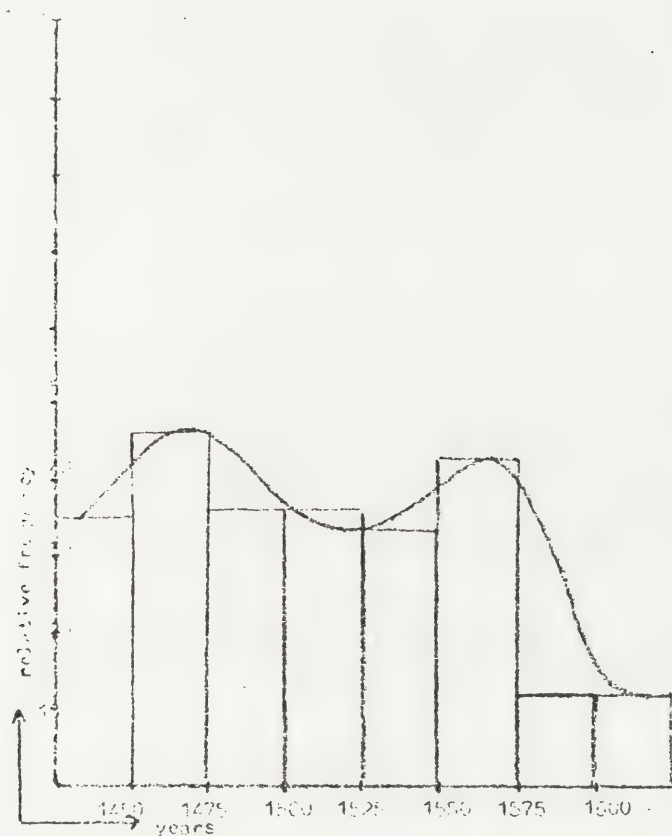


Fig. 2. ...

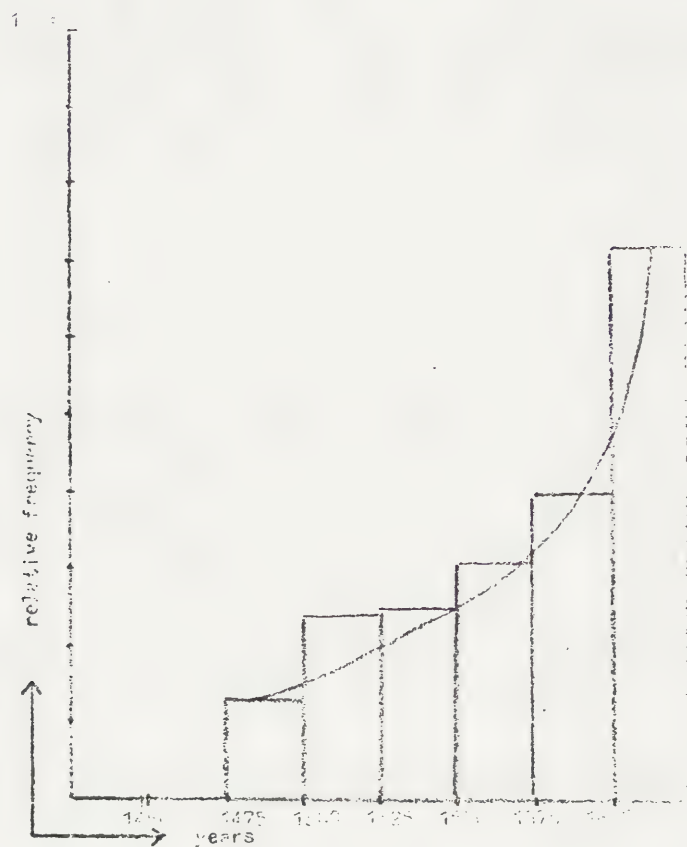


Fig. 3. ...

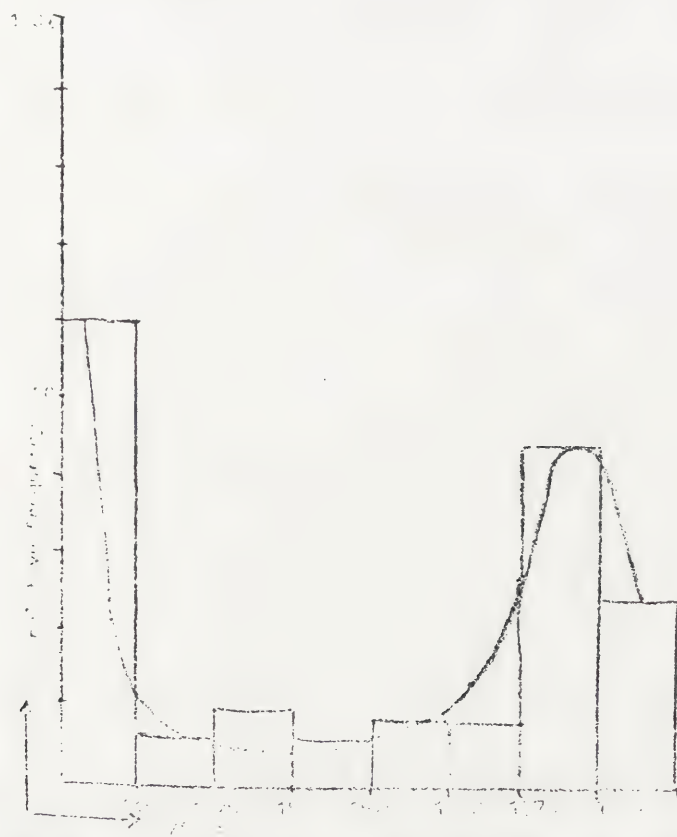
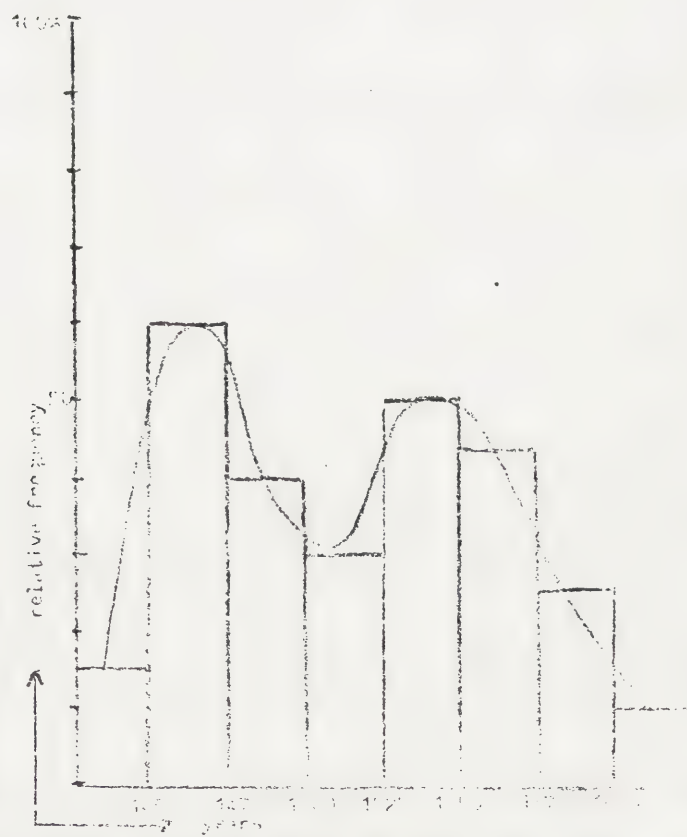


Fig. 4. ...



ITALY

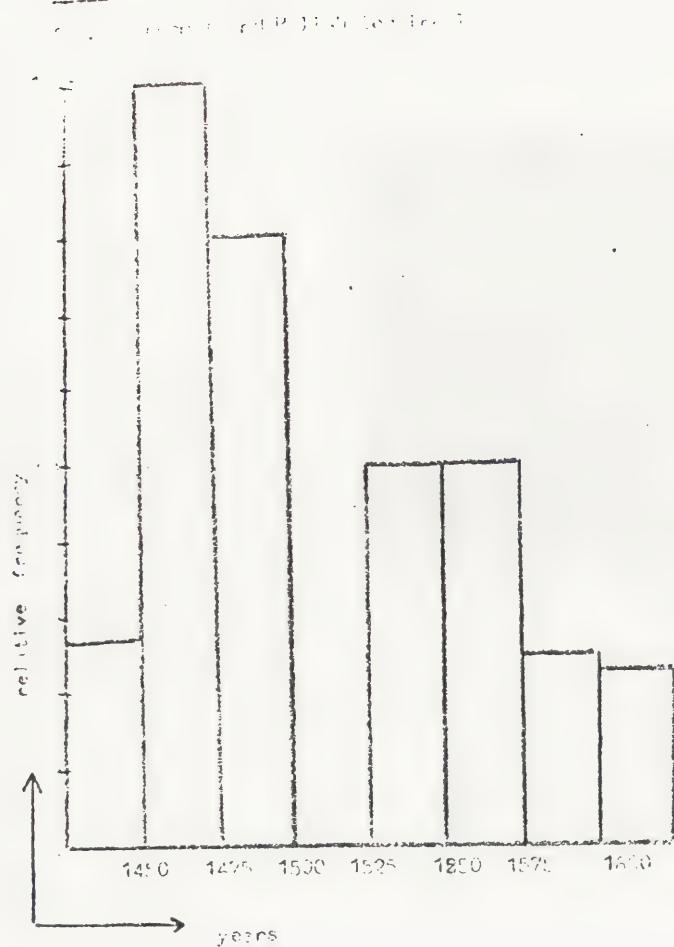


Fig. 7. Relative frequency of the number of years of residence in Italy (1450-1600)

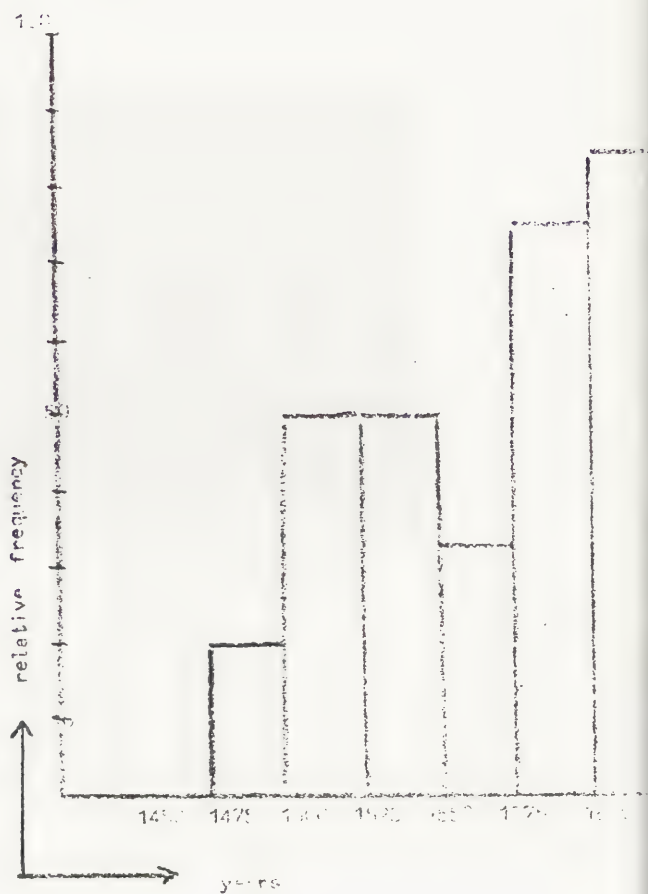


Fig. 8. Relative frequency of the number of years of residence in Italy (1450-1600)



Fig. 9. Relative frequency of the number of years of residence in Italy (1450-1600)

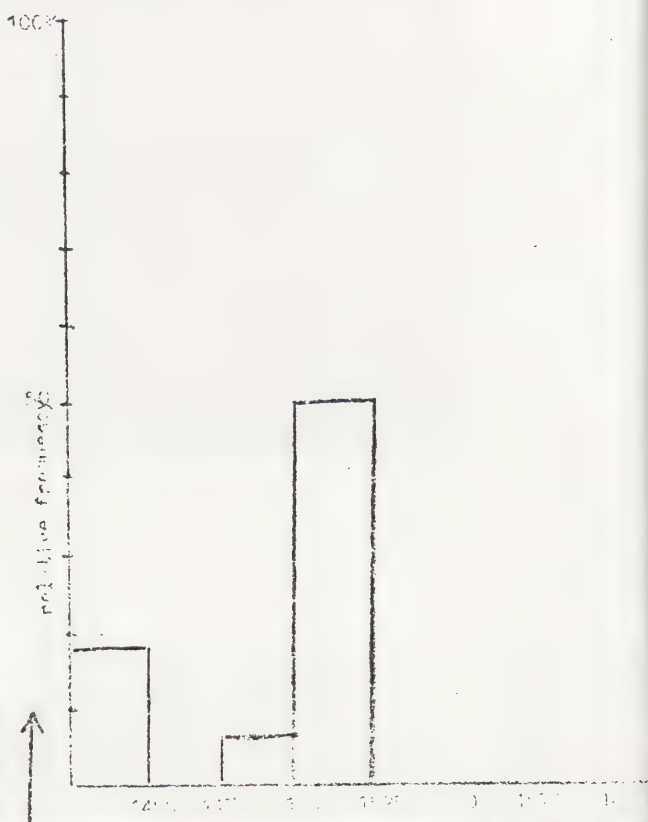


Fig. 10. Mean of Polish Soldiers

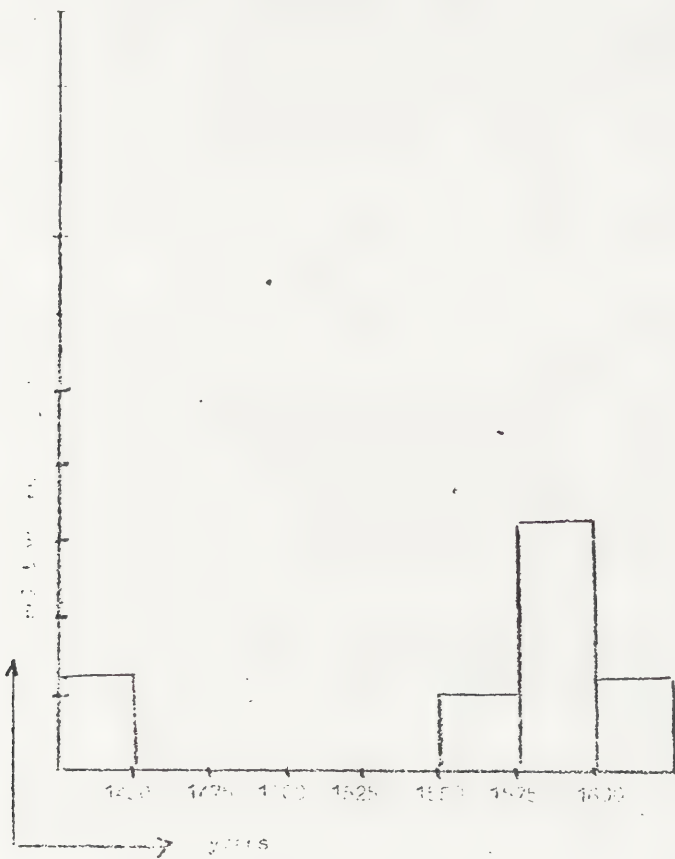


Fig. 11. Condition 1

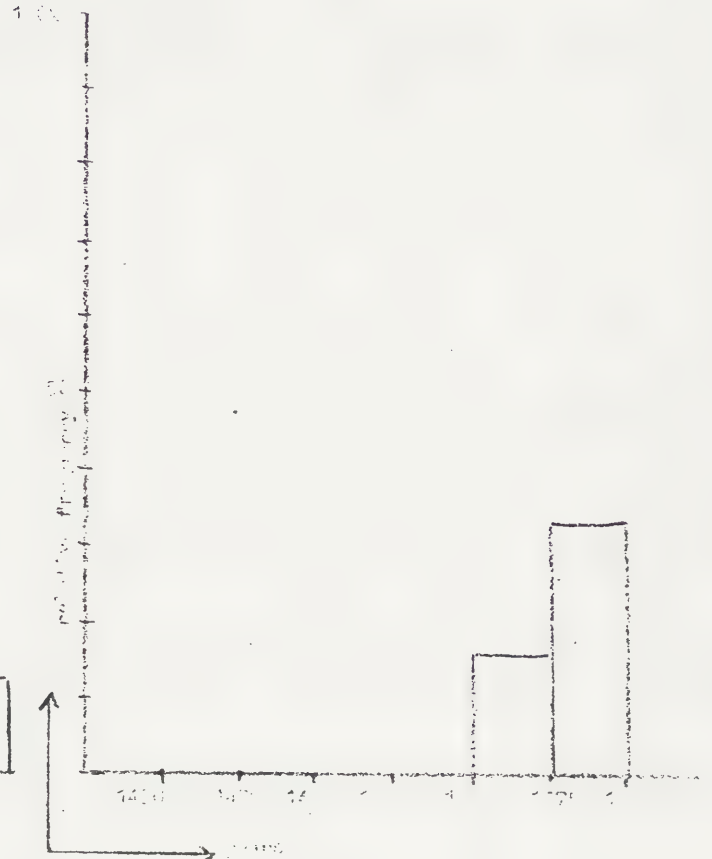


Fig. 12. Condition 2

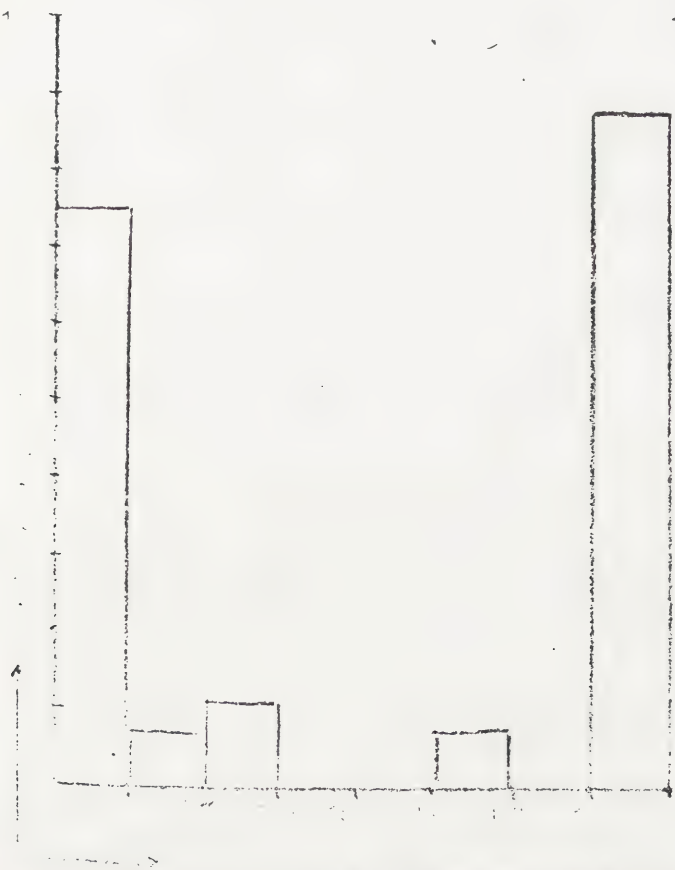


Fig. 13. Condition 3

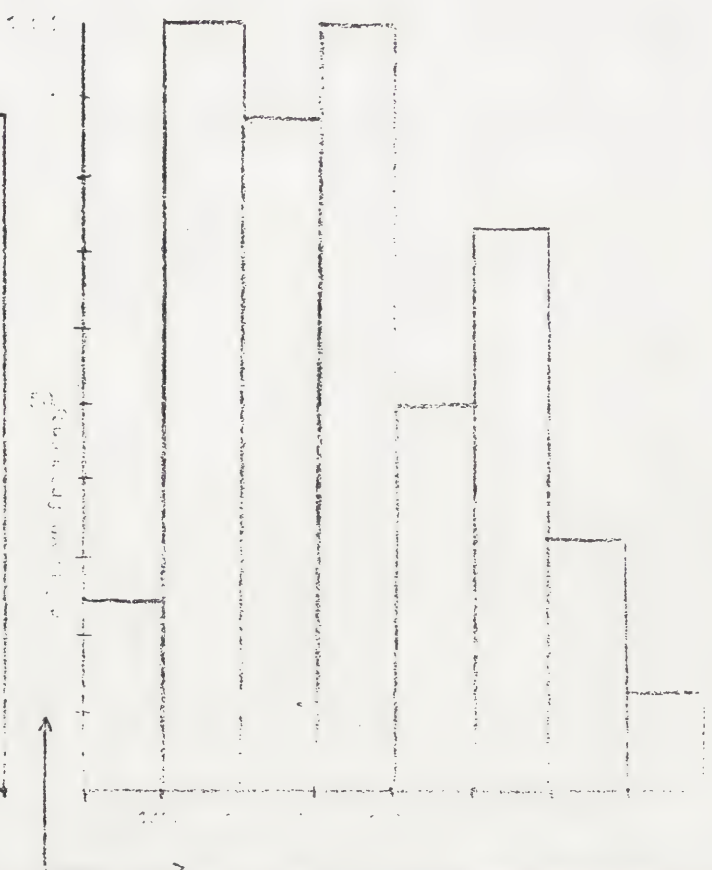


fig.13 WOOL

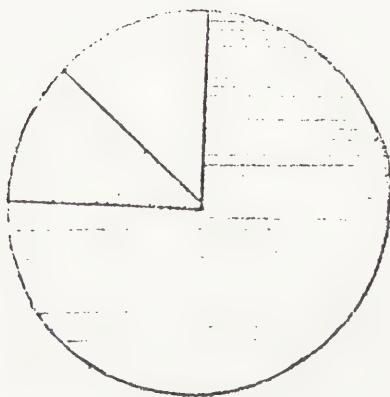


fig.14 SILK



Madder



All varieties of scale insects



Brazilwood

fig.15 Schematic drawing of micro-extraction apparatus, full size.



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S u m m a r y

First a brief glimpse is given on the Überseemuseum Bremen, its collections, its members of ethnographic staff and conservation-technicians, the situation in the ethnographic workshops, their main-programmes and the problems of their partly insufficient equipment are demonstrated,

Then follows the description of the restoration and conservation of a three-seated kajak from the Aleutian Islands, a considerably valuable object, which during its over 120 years of age had suffered from wood-worm, lack of surveying, the consequences of the damage during the last war and those caused by visitors. A first restoration took place in the years following the last war, being of more provisional character due to the difficult circumstances during those days. In 1970 a general inspection of the object commanded a second treatment, mainly dealing with the wooden circles forming the three seat-openings, which ~~were~~ ^{had} nearly totally fallen into pieces. They had to be replaced by circles made of ply-wood, bent into shape on wooden moulds according to the original circles. A exact imitation -as for the material and manufacturing - was not necessary, because scientific research was secured by saving the fragments of the original parts and - as for the didactic information of the visitors - the circles were totally hidden by the seal-skin covering drawn over them in the original state. The supports for the circles in the interior parts of the kajak, made of branches of beech-trees(drift-wood of course), were also replaced by new similar pieces of beech-tree.

The conservation of the seal-skin covering was performed by moistening the hard skin according to a receipt given by the taxidermists

of the Überseemuseum , a solution of commercial salt and glycerine in distilled water. This solution was by and by replaced by massaging in a commercial leather-dressing, the safety of which had been tested during years of use.

The last part of the report deals with the plan to build up a new support for the kajak, which is able to distribute the own weight of the boat to an area as great and adapted as possible by performing a wooden box with a filling of Polyurethan-foam, which is a negative mould of the bottom of the kajak.

The report is illustrated by 10 slides.





Madrid: October 2-8, 1972

J. Gabus (~~Coordinateur~~)

PROBLEMES DE RECOLTE DES OBJETS ETHNOGRAPHIQUES ET
LEUR CONSERVATION DU POINT DE VUE DE L'ETHNOLOGIE
SUR LE TERRAIN

L'enquête sur le terrain emprunte ses méthodes, aussi bien à l'archéologue, à l'historien, au sociologue, qu'aux méthodes classiques d'inventoriage de l'ethnographie. La méthode ethnographique utilisera les fiches d'enquête qui correspondent aux besoins des fichiers de musée, tels qu'ils sont prévus sur le plan international, y compris pour les besoins de l'informatique.

Les thèmes courants seront: habitations, mobilier, vaisselle et ustensiles de cuisine, vêtements, parures, toilettes, poterie, vannerie, cordonnerie, tissage et filage, armes, chasse et pêche, élevage, agriculture, alimentation, transports, jeux et jouets, danses et musique, magie, religion, pharmacopée.

Pour chaque objet, il convient de répondre à un certain nombre de questions, de rédiger, en somme, immédiatement la fiche d'inventaire, dans le cadre de divisions également connues:

1. Dénomination
2. Techniques de fabrication
3. Technique d'utilisation
4. Caractères économiques, sociaux, religieux, esthétiques
5. Origine du spécimen
6. Aire de production et d'utilisation.

Sur le terrain, un plan de cette sorte, bien que déjà simplifié au départ, reste encore très idéal. Dans le domaine des techniques, notre monographie de l'outil était établie comme suit:

1. Formes traditionnelles
2. Relations entre la forme et l'usage
3. Relations entre la forme et le matériel
4. Influences étrangères
5. Influences du genre de vie sur la variété des types
6. L'artisan connaît-il d'autres modèles? Si oui, pourquoi ne les a-t-il pas adoptés?
7. Techniques de travail (photos, dessins, films).

Mais combien sur place, dans les campements, dans la chaude atmosphère d'un accueil d'homme à homme, les expressions "enquête", "système", "méthode" nous parurent souvent ridicules et injurieuses, restrictives: un métier de formules pour "connaître", "bien faire", ou "bien vivre". La vie mérite plus de respect et, nous l'espérons, plus d'intelligence.

La photographie:

La photographie a une valeur documentaire, mais elle se fait aussi signe et référence culturelle.

Le film ethnographique est un complément souvent indispensable, car il peut agir - par regroupements - aussi bien dans le temps, que dans l'espace, si nous songeons à certains films de J. Rouch sur les Dogons.

Il peut être très technique, peut-être trop, quand il s'enferme uniquement dans la seule exécution d'un objet, en négligeant l'environnement culturel (l'école de Göttingen). Il peut s'ouvrir sur un panorama de la vie, comme ce fut le cas pour le film de Henri Brandt "Les Nomades du Soleil". En fait, il est composé d'un ensemble de références, qui devraient correspondre à ce que nous demandons à des archives, à ce que l'historien demande à ses sources (archives, bibliothèques et autres documents écrits). Cette approche, pour les civilisations de l'oralité, appartient à l'ethnographie d'urgence.

La part de l'architecte:

Quand l'enquête d'ethnographie se fait dans des sites qui ont un caractère historique, par exemple les palais royaux d'Abomey, qui couvrent une surface de 37 ha., il importe de faire des relevés, avec la collaboration d'un géomètre et d'un architecte. Ces relevés présentent d'autant plus d'intérêt que les sites, le plus souvent, ne portent aucun signe extérieur de leurs fonctions.

Seules les "grandes coutumes", dans le cas d'Abomey, font revivre tous les sept ans la signification historique du site par ses tombeaux, ses temples, ses anciens marchés, des lieux de danses ou d'autres marqués par des faits et gestes des différents rois.

La part du peintre:

Il s'agit surtout de l'étude des gestes techniques. Ces gestes sont photographiés et filmés. Les outils, les diverses phases de fabrication, font partie également de la collecte d'objets, mais seul le peintre peut isoler l'essentiel, ce que films et photos ne sauraient faire. De plus, une certaine émotion, un certain contact humain que l'objet perd au musée est restitué par le peintre, quand ce dernier a du talent. Nous avons ainsi collaboré avec Hans Erni dans les régions sahariennes, tant chez les Mauritaniens que chez les Touaregs.

Lois et règlements:

Souvent certains pays sont encore mal défendus par les lois et les règlements douaniers. Divers systèmes sont utilisés, qui concernent aussi bien l'archéologie, que l'ethnographie.

Questions ouvertes:

Comment protéger et conserver des sites après une enquête? Quels sont les moyens mis à disposition par les gouvernements ou par des organisations internationales?

L'enquête ethnographique et les collections qui en résultent appartiennent à un inventaire culturel et cet inventaire a les exigences des méthodes historiques. Cet inventaire doit être conçu pour les musées d'art et d'histoire (que nous appelons ethnographie dans les pays du tiers-monde).

Dépouillement, publications, collections de travail sont, pour la plus grande partie, entre les mains de chercheurs européens ou américains, mais la collaboration avec les pays intéressés reste l'objectif principal.







Working-group "Ethnographical collections"

Australian Aboriginal Bark Paintings: by William Boustead

The preservation of aboriginal bark paintings presents a number of problems. Hamadic people having from day to day in their perpetual hunt for food have little regard for permanence. Consequently their artistic creations were only regarded as ephemeral.

Today however with the guidance of missionaries and reservation wardens their technique has improved, notably by the addition of more binding medium to their primitive pigments.

Unfortunately the demand for bark paintings has become so great that a good deal of the spontaneity in creation has been lost for ever. Today most of the bark paintings coming out of the reservations must (unfortunately) be regarded as conditioned works.

The collection of aboriginal bark paintings in the Art Gallery of New South Wales and many museums in Australia cannot be regarded in this category.

These are works collected long before aboriginal art became fashionable and for some time their conservation was a matter of considerable concern.

After a good deal of experimentation simple methods of conservation were developed in the Art Gallery of New South Wales some ten or twelve years ago with gratifying results.

Before outlining these simple measures a brief description of the technique used by the aboriginal artist may be of interest.

Preparing the Bark Support:

The bark support is stripped from the stringybark tree (*Eucalyptus Tedronia*) after a careful examination of the surface is made for blemishes such as knots or termite damage. Two incisions are made around the trunk, the distance between varying according to the size of the bark required, which are joined together by a vertical slit.

Formerly this was laboriously carried out with a sharp pointed stone, but today a small axe is used.

The bark is gradually separated from the trunk of the tree with the axe and a stick sharpened to a wedge shape. If the bark is removed dark, the wet, which is the usual custom, it is moist and supple and comes away easily.

The external surface of the bark cylinder is then roughly trimmed before being carried to the camp site where further trimming is carried out until hard fibrous inner layer is reached. Preparations are then made for curing by fire.

A fire slightly longer than the bark is carefully prepared and the outer side of the stripped sheet placed on it. As the moisture is driven out the sheet gradually flattens, the heat enabling supple bark to be trimmed off and assisting in hardening the surface to be painted on.

When the sheet has been flattened to the artist's satisfaction it is removed from the fire, trodden down, sand or logs placed on it, and left for several days to cure. It is then given a final trimming and is now ready for painting on.

This crude and apparently haphazard operation requires considerable experience. The temperature of the fire and the time taken to cure the sheet must be carefully calculated.

Pigments and the Binding Medium.

The palette of the bark painter is an extremely limited one. It usually consists of four basic pigments, red, black, yellow and white.

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limonite, haematite and ironstone.

Often the rock is too hard to be pounded into powder and has to be baked in a fire.

White is usually pipeclay or gypsum and black is made up from manganese ore, or charcoal from the wood of certain trees.

The painting materials are carefully ground between two stones until a fine pigment is obtained. They are then mixed with water to which the juice of the tree orchid bulb (*Dendroium* sp.) is added. Occasionally the entire surface of the bark sheet is rubbed with orchid juice, and pigments ground in water only applied. This often results in a friable paint layer which tends to flake off.

Binding medium varies according to locality. In some areas, wax and honey well mixed together are used. Tribes living close to the sea often use the yolk of the eggs of the sea-going turtle.

Brushes:

The bark painter has a variety of brushes ranging from sticks chewed at one end to produce bristles, feathers or small bundles of human hair which are made up in widths to produce fine or coarse lines.

Stippling of various areas is carried out by the most sophisticated tool in the artist's kit, a flat piece of wood about six inches long and two inches wide in which perhaps a dozen teeth have been carefully cut so that it produces a neat row of evenly spaced dots.

Conservation:

Fixing Frieze Paint:

This was the most immediate problem which faced us when our collections arrived from Arnhem Land and Groote Island.

Much of the pigment powdered away at the slightest touch, the meticulous cross hatching and stippling carried out with such skill were particularly vulnerable.

The most promising fixative then available was Bedacryl 122 X (40% solution in xylene) marketed by I.C.I. One part of the stock solution to five parts of toluol provided an excellent fixative, preventing further loss without creating undue gloss on the bark background.

Usually the fixative could be sprayed on using low pressure but in severe exfoliation it was flowed under loose paint with fine pointed brushes and then pressed into place using silicone paper to prevent sticking.

Later Calaton CB (soluble nylon) and Paraloid B 72 became available and both have proved to be excellent fixatives in certain cases, although Calaton has certain limitations.

Most bark paintings are now treated with a fixative before they leave the reservations and usually survive the journey over rough bush tracks in four-wheel drive vehicles without substantial paint loss.

When they reach the conservation department they are carefully examined under a low powered stereoscopic microscope for any signs of mould growth, insect infestation and irradic paint.

Insect infestation is usually mild and easily treated with Aldrin or Dieldrin. If mould is present spore formation is lightly brushed off or sucked off with a small vacuum cleaner and both sides of the bark support treated with Shirlan or Copare. Recently we have been using a 5% tri-butyl tin oxide in white spirit with excellent results.

If necessary the painted side is sprayed with another coat of fixative, taking care that it impregnates rather than form a skin which ~~causes~~ results.

The painting is then ready for flattening which is necessary in most cases if it is to be exhibited and also to prevent further strain being imposed on the brittle, inflexible painted design.

The painting is placed on the vacuum press plate, a polythene membrane sealed with packing tape placed over it and gentle pressure applied, to ensure that further cracking, if any, does not occur. The transparent polythene as opposed to thin gun rubber membranes provides greater visibility.

If new cracks appear, or present ones extended pressure is reduced and the bark taken out. A layer of cotton wool dampened with distilled water and Lissapol (0.1 solution) is applied to the back of the bark which is placed back on to the vacuum table and subjected to mild heat to approximately 300C. for about one hour. Vacuum pressure is then applied very gradually.

If splitting is still apparent, pressure is reduced and more heat applied. Finally it is usually possible to flatten the bark support without extending the cracks. This process does not work so well with very old bark paintings which have suffered neglect throughout the years and attained permanent warp. In such cases the curator is called in and he decides whether a few splits should be risked if he is to exhibit the object.

When it has been demonstrated that the bark can be flattened without too much extension of the splits the reverse side is coated with solution of a co-polymer polyvinyl emulsion of the required viscosity.

The required viscosity is determined by the age of the bark, its degree of warp, its fragility and the condition of the painted design.

No heat is applied but pressure is maintained for a period of from three to four hours. Pressure is then turned off, the bark is left on the table still under the polythene membrane, a sheet of plate glass is placed over the sheet and weights applied.

The bark is removed next day and except for holes and natural configurations is usually flat enough to be fixed to a panel and exhibited.

Results so far have been from 90 to 95% successful.

Obviously the display and storage of a bark painting cannot be carried out by traditional methods.

Screwwyes cannot be used to hang it, and battens glued to the reverse side accommodate the screwwyes will only restrict mild flexing of the bark in fluctuations of humidity.

The advantage of the PVA copolymer over other synthetics is that it is an emulsion which reacts slightly to moisture changes in the atmosphere and is to some extent compatible with the movements of the painted untreated side.

To ensure that the minimum of restraint is applied to the bark it is fixed to its display panel near its four corners with a fine single strand of copper wire. The wire is loosely twisted at the back of the panel and its ductility permits it to stretch slightly in response to the bark's movement during climatic fluctuations.

When not required for exhibition the mounted bark paintings are hung on wire mesh frames in an airconditioned storage area. This permits air to circulate freely, facilitates inspection and eliminates the danger of abrading the painted design which so often occurs if the paintings are stacked in storage racks.

Aboriginal Bark Paintings.

are at present restoring ten bark paintings collected in from the Port Essington area of Northern Australia in 1875.

These paintings, the first ever to be collected are the oldest specimens of their kind in Australia.

They came to us in a deplorable condition with either pronounced concave warp and slight splitting or convex warp which had split the bark into two pieces.

Age and neglect has rendered the bark fibres brittle and inflexible. The painted designs have suffered from abrasion, weathering and accumulated dirt and dust.

Microscopical examination revealed, the presence of soot from camp fires, animal fat and viable mould spores.

All of the barks have now been successfully flattened, the colours fixed and grease and dirt removed, fungicides applied and are now ready for exhibition.

Control of Insect Pests

Nest substances which kill insects are toxic to man and methyl bromide is no exception. Because it is odorless its action can be insidious and a halide leak detector should always be available when the gas is used.

When entering an area under fumigation an approved type of respirator must be worn. No other type will do.

According to the Lancet, March, 1956 "Seventy parts per million would be the upper safety limit for short exposures to methyl bromide, and fifty parts per million for exposure lasting over eight hours".

Although methyl bromide will effectively dispose of insects, their eggs, larvae and pupae, it does not render the object immune from further infestation. To ensure that this does not occur the object should be treated with an insecticide by spraying it on the surface or more usually vigorously brushing it into the wood, to effect as much impregnation as possible. Small artifacts which have no painted design can be immersed in a bath of the insecticide.

We have found two insecticides that will provide excellent results and use them not only to immunise against further insect attack but also to treat objects which for various reasons cannot be treated with methyl bromide.

1. Dichloroethyl ether diluted with kerosene or mineral turps. The addition of chlordane, dieldrin or DDT provides added residual toxicity which has proved lethal to all stages of the insects because its vapours penetrate deeply into the wood.

The following formula is recommended:

- 1 pint of dichloroethyl ether, 2½ ozs chlordane, or 4 fluid ozs. dieldrin, 5 parts of lighting kerosene.

For this use chlordane should be purchased at an 80% concentration and dieldrin as a 25% emulsifiable concentrate. It should be remembered that dieldrin and chlordane are extremely toxic chemicals and long exposure to them should be avoided. Protective gloves and a respirator should always be worn when treating the infested object.

2. Pentachlorophenol is an excellent insecticide which is lethal to termites, lyctus beetles and dry rot organism. It can be obtained in powder form which is readily soluble in naphtha or kerosene.

We have found a 5% solution in naphtha to be quite effective but some heating is necessary to entirely dissolve the P.C.P.

This formula provides rapid penetration, is quick drying and non-staining. In obstinate cases the addition of a small percentage of dieldrin may be necessary.

Although P.C.P. is not nearly so toxic to humans as some of the other insecticides we have recommended commonsense and care should be observed in its application. The powder can be extremely irritating to the mucous membranes, causing fits of sneezing and slight dermatitis to the hands may occur if protective gloves are not worn.

Naphthalene and paradichlorobenzenes are the most powerful of the "aromatic protectants" group and possibly the most easily obtainable of all insecticides. Although they will kill the eggs and grubs of the clothes moth they are completely ineffectual in the control of termites and woodborers.

Control of Insect Pests:

Ideally, wooden artifacts should be subjected to some form of biological control immediately on acquisition, before they are stored or exhibited. This will prevent infestation of objects acquired previously.

We find that this can best be carried out by subjecting the objects to methyl bromide gas.

Methyl bromide gas is superior to most other fumigants for the following reasons.

- a. It will kill eggs, larvae, pupae and adults of insects, whereas most fumigants are toxic to larvae and adults only.
- b. It is non-inflammable and non-explosive.
- c. It is easy to apply and does not stain.
- d. It is economical in use and leaves no toxic residues.
- e. It has a high degree of penetration and no residual odour.
- f. It is chemically stable and can be stored in steel cylinders for an indefinite period.
- g. Its low boiling point permits rapid vaporisation.

Methyl bromide fumigation can be successfully carried out in a chamber or sealed box at atmospheric pressure, in a vacuum chamber or under a sealed plastic tent.

Vacuum chambers are large, cumbersome and expensive, and have to be permanently installed. Their fumigating action is much quicker and more positive. Under vacuum pressure all eggs are killed and fumigation is complete.

Ethylene oxide gas, consisting of 10% ethylene oxide, mixed with 90% carbon dioxide can also be dispensed in a vacuum chamber to successfully eradicate dry rot and surface fungi.

It is inadvisable to subject fragile objects to vacuum impregnation, particularly if they have been extensively damaged by the tunnelling action of insects and fungi. The thin remaining walls would quickly collapse under the pressure.

We have used the plastic tent method in the Art Gallery of New South Wales on several occasions and have achieved excellent results.

The method is very simple and can be used on quite large objects such as canoes, carved ridge poles from long houses and piles of smaller objects.

For example, large Pukemuni grave posts, permanently installed in one of our display courts suddenly displayed evidence of insect infestation. Large holes appeared on the surface and fresh frass was observed each day.

It was impossible to disassemble them for individual treatment and liquid insecticides could not be applied because of their solvent action and tendency to stain which would ruin the delicate painted design.

A polythene tent was made up from .006" thick ICI Visqueen plastic sheeting placed over the poles and the bottom sealed with sandbags.

A dosage of approximately 2lbs of methyl bromide per 1000 cubic feet was fed in, circulation of the gas which is 2.63 times heavier than air was assisted by the use of a circulating fan.

A halide leak detector was used at regular intervals to ensure that no gas

We have found consolidation of decayed wood to be a difficult task, and methods used with apparent success in other countries have on the whole proved to be disappointing.

We do admit however that our experience in this particular field is somewhat limited and restricted to the use of a few synthetic resins available in Australia and a mixture of beeswax and kaolin.

Immersion of the object in a bath of molten wax is usually out of the question because of decorations and painted designs.

We have found that although the Araldite method used by the British Museum does indeed strengthen decayed wood we have found its tendency to form a tough, glossy, insoluble skin on the surface of the object a problem we have been unable to overcome.

Xylamon IX consolidant is not available in Australia and we have arranged to import a small quantity from Germany to test its effectiveness in consolidating rotter damaged wood. We do not feel that it would be effective in strengthening the thin walls of termite damaged objects, and are doubtful whether it would completely fill the large tunnels created by the insect, as effectively as does the wax resin mixture.

It would appear that the material used for impregnation would to a certain extent be determined by the nature of the wood, its cellular structure and the nature and extent of the damage whether by borers, termites or fungi.

Accurate determination of the age of wood is a task usually beyond the powers and resources of the average conservator, but a thin cross section taken from the base of the object and examined under a microscope using 10X to 20X magnification will give some idea of the cellular characteristics of the wood.

Transverse, radial, and tangential sections should be prepared and examined.

It is the custom to loosely term wood as either hard or soft but in Australia and New Guinea, not only do we have hard and soft woods, but also soft-hard and hard-soft woods, again very loosely termed.

The vessels or co-axial tubes of the average hardwood consists of segments joined together. A cross section of a hardwood will reveal that it has very small openings, in contrast with some softwoods which have large openings.

Softwoods on the other hand usually have cones shaped and thick walls, and do not reveal their tracheids on cross sections.

In our opinion any museum conservator attempting the consolidation of a decayed wooden object without some preliminary investigation of its cellular structure is working blindly.

Without this knowledge, complete and successful impregnation will be difficult to achieve, and the correct viscosity and curing time of the consolidant cannot be accurately determined.

The Conservation of Aborigine Bark Paintings and New Guinea Artifacts.

Papuan and New Guinea Artifacts:

The vast territory of Papua and New Guinea with over two million native inhabitants, speaking a thousand different dialects is the source of many unique artifacts produced in an infinite variety of styles.

Climatic conditions range from the hot and steamy coastal areas and tropical rain forest to the invigorating climate of the highlands.

These varying conditions determine the material and methods used by the native artist in the creation of the artifact, and also have considerable bearing on the methods adopted to ensure its preservation.

For example in the Sepik River area ancestor masks are made from carved wood overlaid with a composition of wood gum and clays inset with shells and adorned with boar's tusks and feathers and often surrounded by a fringe of dyed vegetable fibres.

Devil masks on the other hand are made from woven bark fibres or a frame of bent rattan or sago palm strips. The outer surface of the entire construction is overlaid with mud plaster painted with natural ochres and adorned with pig tusks, shell, usually small cowries, and feathers.

In the Maprik area, on the other hand carvings of a highly original style are created from a soft light wood with the emphasis on coloring rather than in the style of carving.

Artifacts produced by the Maprik people are usually masks, full figures and decorative compositions of human, animal and bird motifs, attractively painted, reddish-brown, black, yellow and off white.

In the Trobriand Islands ebony and heavy fine grained wood is used to produce small carved figures, lime spatulas and intricately carved solid tables. Canoe prows, beautifully carved in filigree patterns from a soft fine grained wood are also produced by the Trobriand Islanders.

From the Siassi Islands lying between the mainland of New Guinea and New Britain come platters and food bowls carved with fish or bird motifs from light coloured fine grained wood which is sometimes stained black or kept in its natural state. The Siassi Islanders also produce war drums up to two feet in length, delicately in relief, with the skin of a lizard tightly stretched over the end of the hollowed wood to provide resonance.

Such an infinite variety of materials and methods often makes the task of conserving these objects a difficult one. Techniques which can be successfully applied to an artifact from one district may not work with another from a district fifty miles away. Often the wood is of a different variety and the fixative used to bind pigments and secure decorations will also be different. For example clay with a small quantity of resin will be used in one area to bind feathers and small cowrie shells and wax and resin in another.

When placed in an environment of low humidity the clay binder becomes desiccated and cracks and the ornaments become detached. In contrast the wax resin binder remains stable in fairly low humidities, the decorations

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THE CONSERVATION OF WATERLOGGED WOOD WITH
GLYCOL METHACRYLATE

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I C O M

INTERNATIONAL COUNCIL OF MUSEUMS / CONSEIL INTERNATIONAL DES MUSÉES
COMITÉE FOR CONSERVATION COMITE POUR LA CONSERVATION

Working group for waterlogged wood,

OCTOBER
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1972

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CENTRAL RESEARCH LABORATORY FOR OBJECTS OF ART AND SCIENCE, AMSTERDAM





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To find new possible ways for the stabilization and consolidation of waterlogged wood experiments were carried out with the monomer 2-hydroxyethyl methacrylate, (Röhm & Haas, Darmstadt, Germany).

- Advantages of using low molecular materials are :
- 1) shorter treating times due to the greater diffusion coefficients of the small molecules;
 - 2) in addition to this there is no need for extreme dilution of the impregnating material in the starting phase of the treatment due to comparable diffusion coefficients of water and monomer.

This dilution is needed with the use of polyethylene glycol in order to match the flow of water leaving the wood with the flow of polyethylene glycol penetrating into the wood material.

Because of a large difference in diffusion coefficients undiluted or concentrated polyethylene glycol will partly dehydrate the wood while being in the impregnation bath which may lead to irreversible damages.

The possibility of using pure or concentrated solutions of a monomer will enhance the speed of the process again.

- 3) Due to their smaller dimensions monomers are able to penetrate more easily than macromolecules into the intermicellar spaces of the cell wall, where they can exert a stabilizing influence by fixing the swollen structure of the wood.
- 4) The formed polymer is, unlike polyethylene glycol, a hard material and will give the wood a considerable increase in strength.
- 5) Unlike polyethylene glycol acrylic polymers are not hygroscopic so that there is no risk of greasy surfaces and the treated objects can be stored at a wide range of humidities.

In earlier work (1) for those reasons the monomer methyl methacrylate was used.

In these experiments the water in the wood was replaced by methanol in succession with methyl methacrylate.

After diffusion was complete the wood/monomer combination was irradiated with γ -rays of a ^{60}Co -source at a dose rate of 0.1 Mrad/hr and given a total dose of 5 Mrad.

Although the results were very satisfactory indeed both for small oak samples of 3 x 3 x 1 cm and for bigger pieces up to 60 x 25 x 15 cm, the costs were prohibitive and there were no possibilities to treat bigger objects due to a lack of suitable γ -radiation facilities, such as the huge γ -radiation plant of the French Atomic Energy Commission in Marcoule.

For these reasons heat instead of radiation, was tried for the curing of monomers.

Glycol methacrylate was chosen since in addition to the advantages mentioned above, this material is also water soluble in all proportions and is easily polymerized thermally, and by a wide range of chemically active compounds, (oxidizing agents such as sodium-perchlorate, ammonium peroxodisulfate, organic peroxides; reducing agents such as ascorbic acid, dihydroxyacetone, mercapto ethanol, p-toluene sulfonic acid Na, sodium bisulfite; and by organic and inorganic acids and bases).

It was also noted that a mixture of glycol-methacrylate and a pulp of waterlogged wood gelled in a few hours at room temperature.

At 10-15 °C however, glycol methacrylate is perfectly stable during months in contact with the waterlogged wood. on the condition that the concentration of water in the monomer is kept low, and also local increase of water content at the surface of the wood is avoided by circulating the liquid, for it was noted that strong dilution with water may cause premature gelling of the monomer.

In practice this means that either the excess of glycol methacrylate should be big enough so that it will not be diluted to a concentration less than 90 % by the water from the wood, or the impregnation solution should be dehydrated occasionally.

Experimental:

Pieces of an oak plank from a 17th century ship wreck, drained at the Zuider Zee reclamation, 36 x 21 x 4 cm, were soaked in pure glycol methacrylate, containing 200 ppm hydrochinon, used as received from the factory.

The liquid was circulated at 15° C through a thermostat during 2 months..

After that period the samples were cured at 70° C during 2 days without adding curing agents and without any prevention to slow down the rate of evaporation of glycol methacrylate.

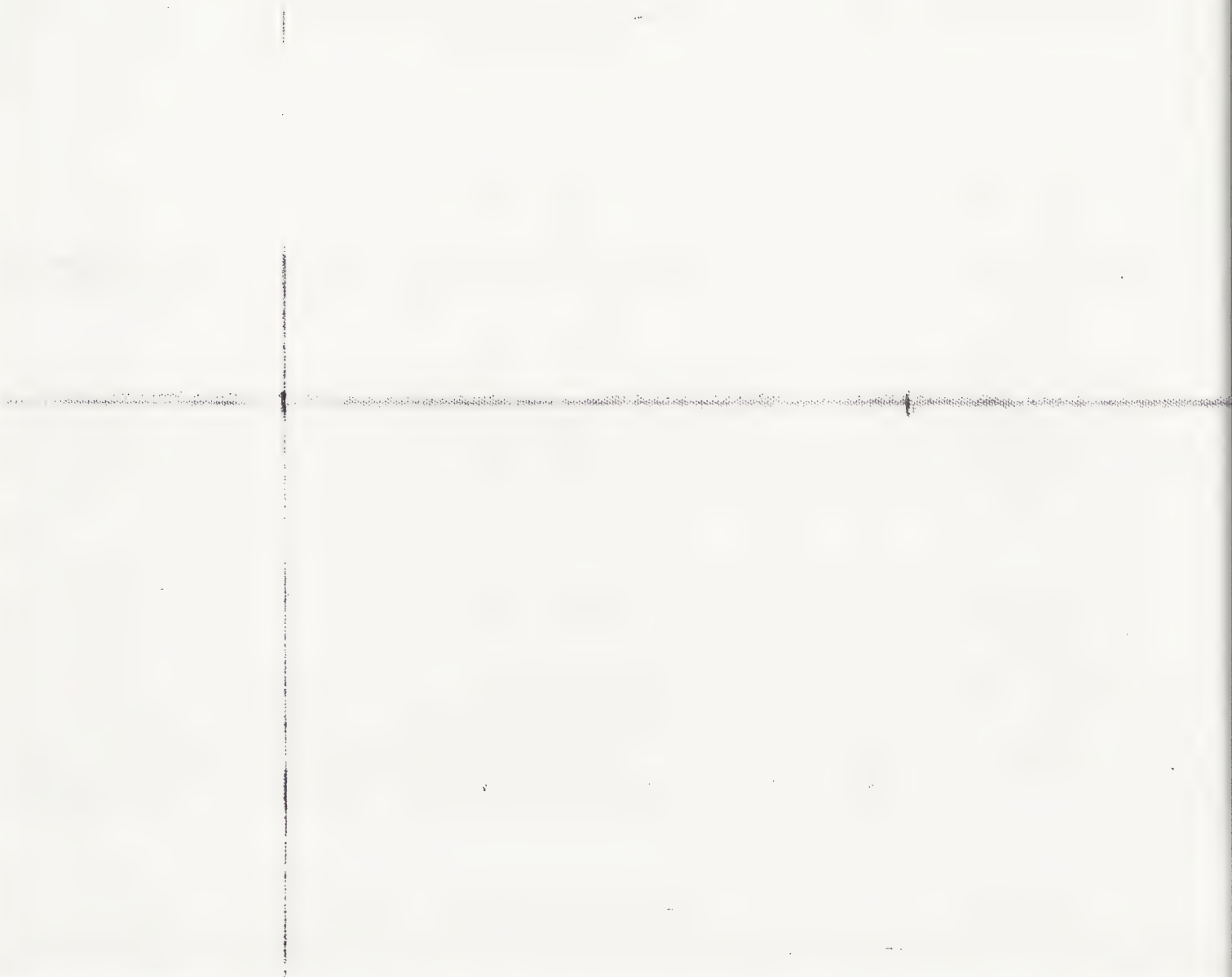
The evaporation was considered to be negligible, since even at 70° C the vapour pressure of glycol methacrylate is still very low, (estimated between 1 and 2 torr). When dried without treatment the wood lost 70 % of its wet weight and showed a tangential shrinkage of 20 %.

After treatment the tangential shrinkage was reduced to 4.9 %, (in comparison with 8.2 % for the maximum tangential shrinkage of fresh oak). The weight loss after curing and drying was only 24.6 %.

Experiments are now being carried out to explore possibilities for the application of this method for the conservation of big pieces of waterlogged wood. For that reason parts of 17th century ship wrecks, including complete construction details are given a similar treatment as mentioned above. One piece consists of a part of the bottom of a ship, 100 x 100 cm, including supporting beams 20 cm in thickness, and another being a 60 cm long middle part of a ship consisting of a bottom, 100 cm wide and a side part 100 cm high, including beams of 20 cm cross section.

1)

Munnikendam, R.A., Conservation of waterlogged wood
using radiation polymerization,
Studies in Conservation Vol. 12, 1967, No.2, pp 70-75.







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RAISING THE AMSTERDAM

SONO TECHNICAL STUDIES ON RAISING, PRESERVATION AND CONSERVATION
OF A 18TH CENTURY DUTCH SHIPWRECK FROM THE HASTINGS/CHANTER COAST.

G.D. VAN DER HEIDE.

ICOM

INTERNATIONAL COUNCIL OF MUSEUMS / CONSEIL INTERNATIONAL DES MUSEES
COMITEE FOR CONSERVATION COMITE POUR LA CONSERVATION

Working group of waterlogged wood.

OCTOBER

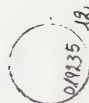
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1972

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Raising The Amsterdam ?

Some technical studies on raising, transport and conservation of a 18th century Dutch shipwreck from the Hastings-Channel coast.

D. van der Heide, Archeological department of the IJssel-lake Development Authority.

In April 1748 the directors of the Dutch East India Company decided upon the building of new ships of their fleet among which the 150 feet long ship Amsterdam. This type of 150 feet ships was then rather new since 1741 no more than 20 were built before the Amsterdam was launched in 1748. The Amsterdam must have been built on the ship-building yard of the V.O.C. in Amsterdam. Building this ship has only been taken a few months. The ship sailed on the 15th of November 1748 from Texel. Willem Klomp was the Captain-Lieutenant. With a length of 150 feet, 150 "lasten" and with 335 hands on board: Maritime-employers 204, military 128, and 3 passengers, it made its maiden trip. But it was not a very lucky start. The cargo which was a big vessel for that period, left Texel on the 15 of November but returned at the 19th. It left Texel again on the 21th and came back once more the 6th of November. More than a month later, on the 8th of January 1749 it went of again and short afterwards it came in difficulties and stranded on the Sussex-coast between Hastings and Beachy Head.

About the money on board of the Amsterdam, everything is well known from the Journal of the chief bookkeeper of the chamber of Amsterdam, which is in the "Algemeen rijksarchief" in the Hague.

But not only about the money on-board, also about beer and wine (new Bergerac) there can be found descriptions about what was on board of the ship, which was bound for Batavia: 56 cases of wine, 129 casks of beer. There had also be bought for the fleet large quantities of Rhine-wine, meat from Westvoldinger oxen and bacon from Groningen, Frisian and Irish butter and Edam cheese. This apart of coarse from the private crews' and passengers' goods. The names and ranks of all the people on board are known from the 335 payroll, which was found back in the archive. It is known that there where bad storms in the Northsea and the English Channel when the Amsterdam and other ships arrived in the area in January. Papers from february 1749 brought the news from Great Britain that in several harbours of England and Scotland many merchantmen sailed ashore and other ones had been wrecked. Among them was the East India Company ship Amsterdam being most of the people and cashed salvaged. The ship stranded near Hastings in the Sussex-coast, where the most precious goods and stocks were salvaged and brought to the Royal warehouses. Of course there were many people in the neighbourhood who hoped to get a part of the materials on board, but they did not succeed so much. However it is not sure that besides the money from the

ship very much of the other cargo had been salvaged. There is known from eye-witness two days after the stranding that on the Northsea already 50 men should have died and many more when the ship stuck on to the ground at Hastings.

There may be some discussion about what have been salvaged from the wreck. Sure is only that the silver had mainly been salvaged, besides a small amount of silver bars (20) had been taken from a chest of silver. These were later taken from a smuggler who forced this chest of silver bars. All the silver, except the 16 bars who were lost, were requested to Amsterdam. The other cargo is only mentioned 3 cases were merchandise, probably including the chest with gold and silver facings. Sure is however that the wreck, the cannons, anchors, cables and other things remained on the coast. There was decided in Amsterdam to sell the wreck. The correspondent of the company in London has also been approved to the selling of the cannons, anchors, cables a.s.o. from the wreck. But in the bookkeepers' journals nothing has been found about a selling.

We cannot be very astonished about this question. When the ship was stuck on the coast it sunk down in the quicksands of the channels-beach in rather a short time of only a few weeks. Eye-witness on the wreckside declared that the vessel sunk down in a short time. Besides that was the situation of big tidal changes of (nowadays) between 8 and 12 meters far from ideal to take cargo from the ship, so that we may be rather sure that at least most of the materials which were underneath the orlopdeck were kept there without possibilities for salvage. In England was known about the Amsterdam wreck that the unloading of the wreck after the moment of wreckage had not succeeded very much. And also afterwards in later years the wreck, however it will have attached the interest of many people coming to the coast, has in its situation not given very much possibilities to take off the things which stayed underneath the decks. There were kept both decks as has been found out by the youngest survey to find out what remained from this wreck. So was declared too, short after the wreckage, that the owners did not save any quantity of goods from the ship before it was so much sunk in the sands that it was impossible to get at the cargo, the ship always being full of water. And another described short after the wreckage that it was almost werved as high as his upperdeck so that it then should be feared that most part of the cargo should be perished in the sand. There was tried to burn the decks and blow them up with gunpowder, but as the ship was continuously under water people could not fix the barrels of powder at a proper place. The Duke of Newcastle has sent a group of soldiers to secure the wreck at the site.

In the first half of the 19th century sometimes people made attempts to dig down in the hold of the submerged ship. Then sometimes objects were found but it was not possible to do so much by lack of time between tidal-changes and by lack of big digging material. So in februari 1827 poor people from Baxhill cleared out sand and found various glass tumblers, liquor glasses, metal cups, stone, glass bottles, and dutch knives. The group discovered in the same year Dutch china jars, glass goblets, wineglasses, knives and square bottles. The lower deck was supposed to contain a great quantity of sheet copper.

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Other materials that have been found are leather objects, objects of timber beams, bronze and iron cannons a.s.o.

Until 1969 the Amsterdam wreck layed in peace on the English Channel coast. But in August of that year a contractor firm, installing a sewage pipe under the beach of Hastings looked with interest to the wrecksite and with there mechanical diggers they tried to dig at particular low tide in the wreck. Then they found glass bottles for wine, pewter spoons, candlestick and five bronze cannons. In fact they realised themselves in the mean time that they had no real rights to go on after the first finds and so they contacted the Hastings museum. Along this way they came in connection with the Britisch Council for Nautical Archeology and with mr. P. Marsden from the Guildhall-Museum of Londen. From this side there was real interest in the Amsterdamwreck.

Of course it would be worthwhile to know what remained from the ship itself. A new short survey was planned at special low tide. That is the only possibility to work at the site, but even then only for a short time. The Archeological Unit of the Britisch Broadcasting company had interest too and a film was made during both times that short surveys for nearer orientation were undertaken. During this campaigns different objects came to light on behalf of shipsequipment and domestic, personal objects. Among all this different large blocks, wooden teggle, leadtopped iron weights, pieces of rope, rolls of ribbon and some other te ile materials, pewter, horn, and bone buttons, a brass tobaccobox, a needle dolly in turned wood, a drinking pot of lead, horn double side, finally toothed combs, clay pipes, a ladies fan of ivory, brass cuff links, a partly ivory flute, glass of a lantern and pale- bleu glass beads came to light. There were also found ceramics or stoneware, bellarmine jugs of different types, whitish, greyish-brown tigerware or dark brown, which have been made in different centers of Germany. An earthenware pan, Delftware, porcelain fragments of saucers or low plates with blue floral patterns, and slipware were also brought above water and mud. Furtheron there were found green glass bottles of two different types, many of which contained red wine and were still sealed. There were also square bottles which may have contained- they all were broken- strong liquids. There were other glass objects as tumblers, wine glasses and wooden objects as the blocks, a barrel stave with incised mark, circular scoops and a cask lid. On metal came sheath knives, pewter spoons of different types, handles, knife and forks

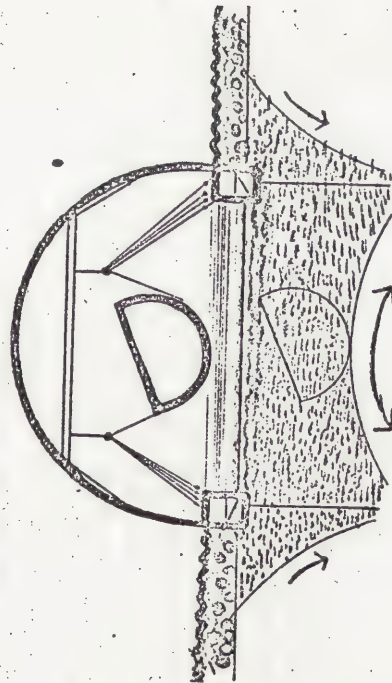
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In that stage a lot of problems came to light too, together with the wreck itself and the artifacts from the ship. The first thing to be answered was who is in fact the owner of this original Dutch wreck on the English coast. In cases of finding a Dutch wreck from the V.O.C. the ministry of finance, who is the owner, claims ownership and requests a part of the worth of which is brought above water. In the Amsterdam case the Ministry of finance of the Netherlands claimed the wreck on base of the fact the Dutch government got all the rights and duties at the end of the 18th century, when the V.O.C. ended its activities and all was taken over by the Dutch government. But also the Ministry of Culture, Recreation and social work showed interest in the Amsterdam. That is why, when the English decided to accept the Dutch ownership claim, it was not difficult to prove that the ship was really the Amsterdam. It also meant that something most be done with the wreck. The salvaging problems came in Dutch hands and the plan was made that the ship should be brought back to the Netherlands if it would be possible anyway to realise lifting and transport. The planning started by the first steps of an technical Anglo-Dutch workgroup to study the project. What should be known may be grouped under three heads:

- A. The method of raising the wreck
 - B. The method for archeological examination the wreck
 - C. The method of preserving the wreck itself intact
- Needless to say that the operation also involves a great number of minor problems but also very big problems of building up an organisation which has to cover the whole project including the decisions about the in a.b. and c. called methods. Not only that but also about the studies where and how should be placed after being raised, raising funds for the whole of course really expensive project and also on exploration as soon as could be possible. For this project are funded two committees: one off the Dutch officials from the ministries, and one of Foreign Affairs in which also the Dutch specialists from the Anglo-Dutch workgroup found there places. This workgroup was formed by specialists who have had much to do with shipbuilding-history, ship archeology problems, and which problems of conservation of material out of the sea. The workgroup can ask in cases it is wished the assistance of other specialists so as geologists, chemists and technicians for specific details. In order to come to a proposal regarding examination of the possibility of raising the wreck Chief-Engineer N-Smit, who was many years working in the new-work methods department of the Holland Delta-works, made a study about the situation on the wrecksite. From British study there is already known that the seabed on the wrecksite consists mainly of somewhat stratified fine sand with a large proportion of silt. At one side of the wreck there is a mass of rather heavy clay, older sea-clay. The situation is that at the time when the ship came to the coast there was a small bay in this area with a narrow opening. Nowadays this bay has disappeared, but the ship may have tried to enter the bay when it lost its rudder and was taken

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the spot by anchoring. It was as described, helpless driven to the place where it stranded. After stranding the wreck evidently affected the current pattern and caused sand to be deposited and it proceeded the silting-up process. Most probably there is from the hold of the ship left a depth of 7-8 meter. Study was also made of the tidal situations which may be expected when work should be done on the wreck site. Of course it is necessary to carry out experiments on examination of the ship without hindrance from the continuous tidal movements which cause current and sediment movements. That means that the wreck must be cut off from the surrounding water by means of a cofferdam or some other construction. This should be high enough to prevent waves overtopping it and it should penetrate deeply enough to prevent water seeping in from the bottom. Some kind of roof would be effective in providing protection against climatic conditions. It would- so is the opinion of the technical workgroup- turn the site into a kind of workshop, in which excavation, cleaning, investigation and recovery of the vessel and its contents could proceed. For that purpose also artificial lighting could be installed. This is very necessary in order to start preserving the ship and its contents in an early moment.



In this drawing, taken over from "The Holland Herald" the idea of Mr. Smit is showed; the big pontoon in which the work on the wreck can be done.

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The idea of Mr. Smit for this special purpose of materials used, is that it would be a great advantage if the cofferdam-cum-roof could be used as a camel.

There is thought of a construction that would enable the wreck to be approached by water during much of the tidal cycle: a steel pontoon. This pontoon could be supplied with electricity by a generating set. Fresh water could be obtained from tanks on the pontoon itself or piped from the shore. The pontoon must be capable of floating and of withstanding hydraulic pressure and wave impact. The pontoon would consist of a float bearing a superstructure.

The space enclosed would be large enough to embrace the ship and the space around it. The pontoon would take the form of a closed box: it may contain ballast tanks and a workshop, drawing office, photographic and preservation laboratories and storerooms. The superstructure is planned to cover an entire internal area of 22 m by 52 meters (the ships length is 48 meters), including the longitudinal sections, so an area of 1,144 m² including a first floor of 600 m² affording accommodation for pumps and generation sets. This platform would be above water when the pontoon had been sunk. From this the suction pipes, etc. for drainage could be installed.

The seabed around the wreck would have to be levelled before sinking the pontoon on to it. When this pontoon is in position a hydraulic seal would have to be placed between the bottom edge of the pontoon and the bottom. Then the subsoil will be drained.

The ring-shaped part of the pontoon could consist of four box-shaped sections: two for the ends and two for the sides. These sections could be joined together on the water. When the pontoon is in position the two end-sections would function as ballast tanks and that is why they would be made as closed units. The longitudinal sections can be used for different purposes as wanted. The sections of the pontoon would have pipes with valves extending as nearly as possible to the bottom; they would be used to fill or empty the ballast tanks and enable the water inside the ring to follow the tidal rise and fall until a watertight seal between pontoon and sea-bed had been effectuated. There could be thought of a lot of detail in order to realise an optimal good use of the pontoon in which the ship must be kept for rather a long period.

Very important for all is the nature and composition of the sea-bed in relation to the type and capacity of the drainage-system required. We will not go into detail problems of this technical material for raising and transport. The working area has to be pumped dry and the sand must be removed as deliberately as desired. It could be deposited in a wet silo

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and then pumped overboard so that any object within the working area inside as well as outside the wreck can be located and recovered. One of the most important things in this wreck is, particularly the possibility to the location of all the objects on board and the way those have been towed. During the cleaning process any damage in the hold of the ship would be discovered and this will be of importance on behalf of the further transport. The wreck would remain suspended above the water-line of the floating pontoon, which would then be deeper in the water. It would then be possible to transport the whole thus over sea. About examining the wreck must be thought about different things:

- a. the shape and construction of the wreck,
- b. the manner in which the ship was loaded,
- c. the examination of the entire cargo,
- d. that of private properties of the people which were on board when the wreckage took place. This work must of course be done properly but it is not to be allowed to delay the operation of the raising of the wreck. It will not be necessary to prepare drawings of the entire ship while it is be raised. In this case stereophotogrammetrical methods are in study if they can be used in the circumstances of this work in- and outside the ship. That in order to establish everything on to the point where it is the situation of the Amsterdam-wreck.

The way in which the cargo is stowed must be recorded, this will be more difficult than recording the vessels outward appearance. It is necessary to remove at least some of the sand and clay from the hold to lighten it and to reduce the outward pressure as much as possible while the inward pressure is being removed from the outside of the hull. Then sand and clay inside should be removed carefully. It might be advisable to stir it up with water and strain in to ensure that nothing gets lost. The position in which every object is found must be recorded if possible. It could be tried to do that too by stereophotogrammetry, but it is not sure that it is possible to do that. So what is certain however is that meticulous cleaning, washing and recording will be very time-consuming; it might therefore be advisable to consider whether the mud could be left in the hold until there is better possibility without delaying the work of raising and transporting the ship. If that would be possible there will be better possibility for recording all the objects in the ship and those can be removed afterwards.

It is essential that the positions in which the artefacts are found inside the vessel be recorded that the matter should be given careful consideration with a view to drawing up some definite plan. Of course the operation depends to a great extent on the

heavy mud that is difficult to remove. Closely bound up the foregoing is preserving the wreck intact. This preservation would deal with two aspects: a. preserving the wreck itself and b. preservation of most of the artefacts found in the ship.

It should be mentioned that the wreck lies in the fairly salt Channel-water. It would therefore be advisable to consider whether all the material to be preserved should be treated at once with fresh water or whether the transition from a salt to a fresh water environment should be effectuated gradually before the preserving process starts. It is essential that any wood from the wreck and any other material removed from the ship should be kept wet until such time as the definitive preservation process can be started. It will almost certainly be necessary to reduce salt content of some of the materials gradually to prevent any abrupt transition from one environment to another from upsetting after partially or completely any preservation process that may be contemplated. The salt content would have to be lowered gradually at a controlled rate and the object would have to be cleaned at the same time. It would be mentioned that the articles found in the "Vasa" at Stockholm were kept in their original environment in natural basins in the rocks near Stockholm. This is certainly impossible in the Netherlands, partly because of the pollution of the sea off the Dutch coast. Natural basins for keeping all sorts of materials are not realisable along the Northseacoast, nor would it seem possible or even desirable to store any finds along the Channel coast. Basins or tanks will be needed in which any article found in the ship can be washed for some time in fresh water to remove salt, minerals, a.s.o.. Consequently the matter of the fresh water to be used any when it should be used should be studied in advance. Objects should be sorted by material and be basin or tank. The archaeologists will have to treat different materials and even from the same material - such as timber for instance - different qualities. This may depend on the way they are pretreated. There is a variety of ways; waterlogged wood can be of different quality: it might be sawn in a special manner, which may influence its quality now, it may have been somewhat rotten or rather new as in the case of the Amsterdam /and the "Vasa" too/, it may have been painted, covered with pitch or tar and it is often of various thickness. There are many other materials such as wrought or cast iron, copper and brass, bronze, pewter, leather, rope, a wide variety of cloth especially wool and linen, bone, ivory and horn, earthenware, stoneware, glass and various other substances such as remnants of food, candles, oils and fats, tarproducts, alcohols, a.s.o..

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Ship water at the wrecksite should be analysed for devising a substitute environment and for finding out the best way of changing over from a salt- to a fresh water milieu as an early stage for coming to preservation. Preserving the vessel and its contents will be a formidable undertaking.

But it is impossible to know how much material there will be to keep and treat. Consequently it is also impossible to set aside a particular space for the treatment of what may be found. That is why the provisions made for temporary storage will have to be very flexible indeed. There will have to be adequate alternatives. It will only be possible to dry a few of the sorts of finds and most of them will have to be treated in transitional tanks providing a gradually changing environment. Dutch scientific institutions cannot at the moment be expected to provide facilities for the effective treatment of all the material accordingly. Equipment will have to be made and bought and staff /temporary if necessary/ will have to be engaged to work under expert guidance. The tests to determine the best methods of treatment can be carried out in existing laboratories. But much work must be done on the temporary or definite place of the wreck. Among this X-raying of materials would be necessary at the site too. The Central Laboratory at Amsterdam would certainly be called upon to assist by conducting experiments and giving advices. In any case, a workshop in which some laboratory work in the way of essential simple progress checking could be done, should be attached to the main workshop and storagerooms. It will be necessary to make provisions for restoration as well as for preservation. Space and equipment will have to be set aside both for this and for making plaster casts. Arrangements for all this should be made as soon as possible after it had been decided that raising the ship was technically and financially feasible. The placing of tanks and workshop for all treating of finds are in study as well as the manner in which the finds- of which there will probably be many thousands - are to be treated, accommodated, registered and documented.

The wet material will have to be marked without delay, what will give rise to a number of problems that should be solved in advance. A permanent competent team will have to be set up for the purpose at the outset. It would concern itself with:

- a. the metals, b. the waterlogged wood, c. the earthenware, stoneware and porcelain, d. all other materials such as leather, cloth, rope, etc.

Cooperation at national level is desirable as is the assistance of experts from other countries for certain parts of the undertaking.

adequate technical and chemical studies will have to be carried out to enable the wood to be preserved when the wreck has been raised. It will not be necessary to start using preservatives as soon as the ship comes to daylight, but arrangements will have to be made to keep the timber wet by constantly spraying. Whether fresh or channelwater is used in advance for the purpose will depend on the outcome of the environmental tests. But it is sure that in the first stage channelwater can be used. The pumps and sprinklersystem will have to be incorporated in the pontoon used for the lifting of the ship. The operation of washing the woodwork to remove substances that may hamper the preservation-proces should be started without delay. This will take as is the experience with the wreckmaterial from the Zuiderzeepolders, rather a long time. During that time the fight against the fungi will be of great importance. After this washing of the waterlogged wood the treatment by spraying for impregnation would start. At this moment the best chemical to be used seems to be polyethylene glycol, but it is not ideal, indeed it has certain definite disadvantages. Particular the fact that treatment takes much too long, due to the very slow diffusion-proces that characterizes glycolproducts with their large molecule-structure. It is practically certain that the vessel will be found to be constructed of oak, almost throughout and that little other species of timber will be found. Moreover the wood will almost certainly be in excellent condition and therefore even more difficult to be preserved. In view of this it is even more essential that efforts should be made to discover better ways of preservation for waterlogged wood of archeological importance. As it will take some considerable time to wash the timber and to prepare it in a nowadays way for preservation. It may be sprayed for a number of years without coming to any particular harm. A point that should be considered when preparing the overall plans is that it will be probably impossible to treat the wood of the wreck by any method other than spraying. This preservative will almost certainly have to be in a liquid form and therefore sprayable. The sprinklersystem would have to be of the circulating type to reduce wastage. Tests would have to be carried out to discover heating of the preservative would speed up the proces, and it would be a feasible proposition. The various aspects of the operation " Raising the Amsterdam " are now individually in study and there is real hope that the results of those studies will point out that this 18th. ship will return to the Netherlands. It will not be a second "wasa", it will be a very interesting suggestion about shipbuilding and economic history of the 18th. century.







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COMMITTEE FOR CONSERVATION COMITE POUR LA CONSERVATION
WORKING GROUP: "TWENTIETH CENTURY PAINTING" GROUPE DE TRAVAIL: "PEINTURE DU XX^e SIECLE"

REUNION DU COMITE POUR LA CONSERVATION
MADRID: 2-8 OCTOBRE 1972

GROUPE DE TRAVAIL: "PEINTURE DU XX^e SIECLE"
COORDONNATEUR: P. CADORIN - BALE

ETUDE PRELIMINAIRE

SUBJECTIVITE DE LA VISION COLOREE ET SES RAP-
PORTS AVEC LA PEINTURE

FRANCOIS PARRA - PARIS

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ETUDE PRELIMINAIRE
SUBJECTIVITE DE LA VISION COLOREE ET SES RAP-
PORTS AVEC LA PEINTURE

FRANCOIS PARRA - PARIS

88/86

Subjectivité de la vision colorée et ses rapports avec la peinture.

Ainsi qu'il a été dit par ailleurs, le monde physique qui nous entoure est un émetteur permanent d'énergie, aussi bien acoustique qu'électromagnétique.

L'oeil réagit à cette énergie électromagnétique par une sensation de lumière et de couleur, mais il faut bien concevoir que la sensation ne s'élabore qu'au niveau du récepteur visuel, en conséquence l'oeil en tant que récepteur d'énergie est un facteur important de la vision des couleurs, mais ainsi que nous le savons, ce résultat qui se nomme vision des couleurs est inséparable de la source d'énergie, lumière solaire, ou source artificielle et de l'objet en l'occurrence la couche picturale qui renvoie vers l'oeil humain cette énergie.

C'est une banalité de dire que sans oeil il n'existe pas de couleur et l'on pense communément que, en dehors de l'être humain qui les observe les objets colorés existent tout de même. Non les objets colorés n'existent que parce que l'oeil les voit sinon ils n'existent pas en tant qu'objets colorés, mais en tant que modulateurs d'énergie.

Cet aspect philosophique nous entrainerait un peu loin. La couleur s'élabore au niveau de la sensation à partir d'impulsions codées de la rétine, mais le processus est continu, si bien que la couleur semble appartenir à l'objet en tant que caractéristique de sa surface.

Quand l'artiste peint sa toile, il ne fait que manipuler des substances chimiques qui elles-mêmes modulent l'énergie. Son génie consiste à créer des harmonies en fonction de ses propres données visuelles liées à la physicochimie du pigment et de la préparation de sa toile

ou son support en bois en pierre ou tout autre matière et bien entendu de son imagination ou intuition intimement mêlées aux données précédentes.

L'oeuvre est complexe et le résultat tient compte à la fois de la lumière utilisée, généralement la lumière du jour c'est-à-dire la lumière solaire plus ou moins voilée, des matériaux à sa disposition et enfin de sa vision propre car le résultat qu'il désire en fonction de ses concepts, il ne peut les obtenir qu'en fonction de sa propre vision.

Quand il pose une touche sur sa toile, il la voit telle qu'il l'a imaginée, mais rien n'indique que nous la voyons telle qu'il la voit. On comprend ainsi la complexité d'un travail de restauration dont l'auteur est confronté à un objet en l'occurrence l'oeuvre d'art dont le sens appartient à l'histoire de l'époque à la lumière de la dite époque à la vision de l'artiste aux deux sens de l'expression : vision à support physiologique et vision mentale.

Bien entendu, que la couleur soit ou non subjective, il n'en reste pas moins qu'elle semble plaquée à l'objet qui est l'oeuvre d'art.

L'artiste ou le restaurateur ou le simple spectateur doit se comporter en face du tableau comme spectateur d'un objet situé dans son champ visuel et en dehors de lui.

En conséquence il va s'apercevoir très vite que, suivant l'objet de son environnement, la couleur ne présente pas les mêmes caractères.

Le plus souvent la couleur semble une propriété de la surface des objets qui aide à leur identification et particulièrement dans le cas des peintures à leur définition même.

Plus rarement la couleur n'appartient pas à la surface des objets mais à leur volume, par exemple le bleu du ciel

ou le rouge d'un vin et on perçoit, bien qu'il y a là une différence de nature perceptive. Enfin et cela est encore plus rare la couleur semble une caractéristique de la lumière émise par certaines sources telles que les étoiles.

On peut donc dire que l'une des fonctions les plus importantes de la vision humaine est celle de "balayer" les surfaces colorées, au sens le plus large de l'expression; un champ de blé ondulant sous le vent, étant considéré comme une surface, de même qu'une prairie, alors que ces deux surfaces sont l'ensemble de myriades de petites surfaces des tiges ou des brins d'herbes.

Mais l'oeil s'accommode fort bien, avec la distance, d'une définition plus simple qui est celle de surface globale et lui attribue ainsi une couleur d'ensemble.

Ce phénomène qui semble une banalité de notre vie courante devient aussitôt un problème dès que nous essayons d'en préciser les mécanismes. Disons donc quelques mots de la couleur des surfaces, car ici c'est le problème le plus important.

Couleur des surfaces.

Pour le sens commun un objet coloré, rouge par exemple, semble différer d'un objet blanc par l'addition de quelque chose à sa surface. C'est naturellement une erreur. L'objet blanc diffuse à peu près également toutes les radiations de la lumière qui l'éclaire, tandis que l'objet rouge absorbe les radiations de courtes longueurs d'onde du spectre visible et ne renvoie que les grandes. La couleur résulte donc d'une soustraction ou d'un affaiblissement de certaines radiations. Précisons que les radiations visibles qui agissent sur la rétine humaine sont comprises entre les longueurs d'onde 400 et 700 nm (nm = nanomètre = 10^{-9} mètres = un milliardième de mètre). Naturellement ces radiations provenant de

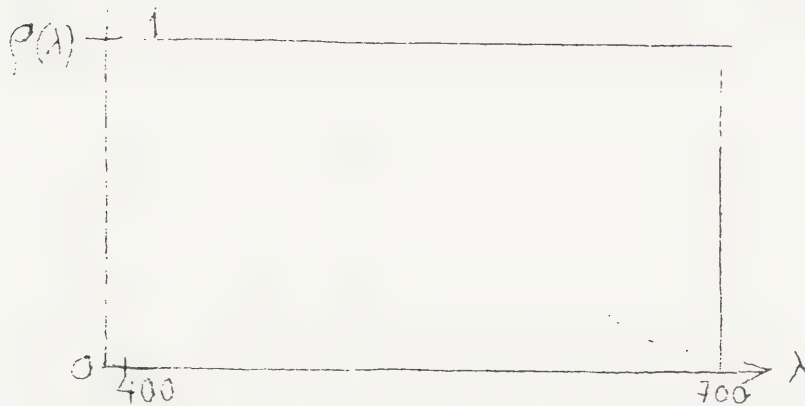
artificielles transportent de l'énergie et pour connaître cette énergie il suffit de disperser la lumière blanche par exemple au moyen d'un prisme et de placer sur les divers faisceaux obtenus grâce à cette dispersion, un récepteur d'énergie.

On constate que pour une lumière blanche les valeurs obtenues pour chacune des radiations diffèrent peu l'une de l'autre, tandis que pour une lumière colorée les différences peuvent être très grandes. On peut tracer une courbe dont chaque point représente une valeur d'énergie en fonction de la longueur d'onde de la radiation. C'est ce que l'on appelle la courbe de répartition énergétique spectrale de cette lumière. Cette courbe définit ainsi physiquement l'émission de la source. En ce qui concerne les surfaces, on ne procède pas exactement de la même manière. On éclaire la surface successivement par chacune des radiations d'une lumière blanche après avoir pris soin de la disperser. Ce que le récepteur d'énergie mesure cette fois c'est le rapport entre ce que renvoie la surface et ce qui arrive sur elle. Le rapport obtenu est ce que l'on nomme facteur spectral de réflexion désigné par ρ_{λ} . Le petit signe λ qui symbolise généralement la longueur d'onde en physique, signifie que le rapport donné par l'appareil qui fait la mesure concerne la radiation de longueur d'onde λ triée dans le spectre.

En faisant défiler ainsi toutes les radiations, on obtient encore une courbe. C'est la courbe du facteur spectral de réflexion ρ_{λ} . Cette courbe définit physiquement la couleur de la surface.

Cette courbe, qui est très importante, permet de connaître la couleur de la surface qui sera vue par un oeil normal dès que l'on connaîtra la lumière qui l'éclaire.

Par exemple, si une surface représente une courbe ayant la forme suivante :



On sait immédiatement qu'elle sera vue verte par un observateur normal si elle est éclairée par une lumière blanche quelconque. Comme généralement on apprécie une surface, soit à la lumière du jour, soit sous un éclairage dit blanc tel que celui des lampes à incandescence, on ne s'occupe généralement pas de l'éclairage et on désigne automatiquement la couleur de l'objet par sa tonalité rouge, verte, bleue, etc .. sans se rendre compte qu'il en est ainsi précisément grâce à l'éclairage, l'objet substituant à la lumière qu'il reçoit les radiations nécessaires à la vision qu'on a de lui en fonction de sa courbe p_λ et de l'oeil qui possède sa propre sélectivité.

Il n'est pas nécessaire de développer davantage ces considérations pour se rendre compte de la complexité du problème de la vision des couleurs.

Bien que l'objet, en l'occurrence l'oeuvre d'art, soit nécessaire pour moduler l'énergie "lumineuse" qu'il reçoit, il n'en reste pas moins vrai que la sensation de couleur est purement subjective. L'intervention du mécanisme physiologique est au moins aussi important que l'objet lui-même.

Il était nécessaire de rappeler cet aspect de la question, car si l'oeuvre d'art a été exécutée une fois pour toutes par un artiste, son voyage à travers l'histoire est souvent émaillé d'aventures qui la confrontent à l'action nocive de la lumière, et des agents atmosphériques, sans

perception de la couleur se modifie avec le niveau lumineux.

Toutes ces propriétés pressenties et analysées par les physiciens il y a plus d'un siècle, n'ont été étudiées d'une façon approfondie que depuis quelques années, mais il reste encore beaucoup à faire pour cerner complètement le phénomène de la couleur. Néanmoins la solution n'est probablement pas très éloignée. Les peintres du 20ème siècle n'ignorent plus ces lois subjectives de la vision et ils les utilisent largement avec succès et le fait nous paraît important car il existe davantage à l'heure actuelle une possibilité de communication du scientifique avec l'artiste, bien qu'il y ait eu un précédent célèbre avec CHEVREUL et les peintres SEURAT & DELAUNAY. Cette possibilité de communication doit être fructueuse autant pour la création que pour la protection des oeuvres et l'assurance plus grande de leur perennité.



The first part of the paper discusses the importance of the study of the history of the English language. It is argued that the study of the history of the English language is not only a matter of academic interest, but also a matter of practical importance. The study of the history of the English language can help us to understand the development of the English language and to identify the factors that have influenced its development. This can be useful in a number of ways, including in the field of linguistics, in the field of literature, and in the field of education.

The second part of the paper discusses the importance of the study of the history of the English language in the field of linguistics. It is argued that the study of the history of the English language can help us to understand the development of the English language and to identify the factors that have influenced its development. This can be useful in a number of ways, including in the field of linguistics, in the field of literature, and in the field of education.

The third part of the paper discusses the importance of the study of the history of the English language in the field of literature. It is argued that the study of the history of the English language can help us to understand the development of the English language and to identify the factors that have influenced its development. This can be useful in a number of ways, including in the field of linguistics, in the field of literature, and in the field of education.

The fourth part of the paper discusses the importance of the study of the history of the English language in the field of education. It is argued that the study of the history of the English language can help us to understand the development of the English language and to identify the factors that have influenced its development. This can be useful in a number of ways, including in the field of linguistics, in the field of literature, and in the field of education.

LogElectronics LogEscan Radiographic Reducer Model R-45
4 x 5 inch film print

Old Delft Corporation of America Delcomat 100 mm X-Ray Copier
100 x 100 mm copy film

QUESTIONNAIRE ON FINE ARTS RADIOGRAPHIC CENTERS

Are you in favor of international radiographic reference centers?
Yes No Perhaps

Would your institution want to have a main center?
Yes No Perhaps

Would you consider having a subsidiary center?
Yes No Perhaps

Would your institution be willing to have its radiographs copied for the system?
Yes No Perhaps

Would the institution be able to make a financial commitment to an international center?
Yes No Perhaps

Does your institution take its own radiographs?
Yes No

If your institution has no radiographic file at present, are there plans for such a file in the future?
Yes No Perhaps

Does your institution make radiographs of its objects when requested by persons or institutions from outside?
Yes No

What information would you like included with each film?

Please return this form to Miss Mary Lou White, Associate Conservator,
The Walters Art Gallery, 600 North Charles Street, Baltimore, Maryland 21201
U. S. A.
This questionnaire is for information only and does not imply any commitment on
your part.

Name:

Address:





1.1/2

THE INTERNATIONAL COUNCIL
OF MUSEUMS
COMMITTEE FOR CONSERVATION

CONSEIL INTERNATIONAL
DES MUSEES
COMITE POUR LA CONSERVATION

Plenary meeting
GROUP 14, REFERENCE MATERIALS.

Réunion Plénière

October 2 - 7, 1972
Madrid, Spain

A Proposal for the Establishment of Fine Arts Radiographic Centers

Mary Lou White
Associate Conservator

The Walters Art Gallery
Baltimore, Maryland 21201

600 North Charles Street
U. S. A.

A PROPOSAL FOR THE ESTABLISHMENT OF FINE ARTS RADIOGRAPHIC CENTERS

The proposal which I am presenting is ambitious but it is one which will be of great value to the entire art community. I would like your reactions to the idea and any suggestions you may have on how it may be improved. The essence of the idea is to have a central reference file of reduced radiographic copies made of all the radiographs taken of fine arts objects. The number of reference centers would depend on how many countries would be willing to support such a system.

While radiographs are being used widely in the museum field they are seldom used in teaching art history or museology, primarily because until now there has not been an easy method of reproducing them in a small size suitable for study purposes. The technological development of radiographic reducers now makes the reproduction of radiographs economically feasible. Because x-rays can tell so much about the structure of objects and paintings, as well as showing their losses and damages, a collection of available radiographs would be an invaluable aid in the training of art historians, museum personnel, and conservators. A comparison center of radiographs would also be a great boon to the established profession. At the moment the only way of comparing radiographs is either by travelling to those institutions which have taken x-rays of the object under study, or by having a photographic copy made of the radiographs. The latter is not only time consuming and expensive as a method of reproduction, but photographs usually do not produce very satisfactory copies as too much definition is lost in the reproduction process.

FUNCTION OF CENTERS

Primary centers would be responsible for the following: copying radiographs; coding information; maintaining a vault copy of each radiograph (which would be available for additional copies to be made when needed); seeing that each secondary center receives a complete set of duplicate reduced copies and catalogued information; making and sending out additional copies on request; providing viewing facilities for radiographs; and having someone trained to interpret the films.

Secondary centers would maintain a complete file of all reduced copies which would be available for study. They would also take orders for any additional copies to be made and send them to the main centers.

REQUIREMENTS OF CENTERS

- A. Primary centers responsible for copying films and sending them to secondary centers. Provide viewing space for radiographs.
 1. Equipment
 - a. Radiographic reducing machine
 - b. Automatic processor for developing films
 - c. Projectors or viewing screens for films
 - d. Space for film storage and easy retrieval of working file
 - e. Vault storage for master copy of each radiograph
 - f. Area for viewing radiographs
 2. Personnel
 - a. Librarian for cataloguing copies and controlling filming
 - b. Technician for copying films
 - c. Assistant to handle mailing of films and secretarial work
- B. Secondary Centers
 1. Equipment
 - a. Viewing room
 - b. Projectors or x-ray viewing screens for films
 - c. Storage facilities for films and catalogues
 2. Personnel librarian for handling and interpreting films

PHYSICAL HANDLING OF RADIOGRAPHS

- A. Filming of radiographs
 1. Films sent directly to a main center
 2. Mobile filming unit (could be used if collection to be copied is extensive)
- B. Determine method of coding information
 1. Card catalogue system similar to Library of Congress
 2. Computer retrieval system
 3. Punch Card System
- C. Information to be included
 1. Owner of object
 2. Artist or school dates
 3. Object number
 4. Title of painting or object date (if known)
 5. Material
 6. X-ray data
 - a. Kilovoltage
 - b. Mass
 - c. Time of exposure
 - d. Tube film distance
 - e. Film type
 - f. Development time
 - g. Original size of x-ray (ruler must be included when making reduced copies)
 - h. Film position
 - i. Operator's name

COSTS

The cost of the films would be approximately 25¢ - 40¢ per copy depending on the volume. Reducing machines and automatic processors range in price from \$16,000 - \$25,000. Grants could probably be obtained to film entire collections of films but funding for the copying machines would be more difficult.

TYPES OF MACHINES

Two of the many types of copying machines available are the Delcomat X-ray Copier and the LogEtronic LogEscan Model R-45 Radiographic Reducer. The Delcomat works on a photographic principal producing an exact duplicate image of the film copied. The LogEscan Reducer uses a scanning spot of light on the face of a cathode-ray tube to produce a negative or intermediate copy from which either a film print or a regular print may be made. This system can vary the density of the original radiograph through the use of a photomultiplier tube. Thus under exposed areas of the original x-ray may be given greater exposure when copied. Attached you will find copies made from these machines. The LogEscan is a film print rather than the negative. The Delcomat copy is the direct first step print. These copies are provided for your comparison of the two systems.

The National Gallery in Washington, D.C. is seriously thinking of adding a radiographic reducing machine to its new research center and would be a primary center in the United States. It hopes to be in full operation by 1976.

I would like you to fill out the attached questionnaire and return it to me. This will give us some idea of how much potential support there may be for the centers and how many institutions would be interested in the project.





13/4

DET KONGELIGE DANSKE KUNSTAKADEMI
KONSERVATORSKOLEN

Peder Skramsgade 8, 1054 København K, Telefon (01) 12 68 60

The International Council of Museums.

Committee for Conservation

Working Group: Training of restorers.

PROGRESS OF PLANS IN THE NORDIC COUNTRIES

K. E. Holm.

Madrid, 2-7 oct. 1972.

8981 67

TRAINING OF RESTORERS.

Progress of Plans in the Nordic Countries.

At the plenary session of this committee in Amsterdam 3 years ago I gave a short report about the - at that time recently published - plans for a school for conservation in Denmark. My report had the immediate effect at the meeting, that this working group was established with the purpose to reveal or encourage common agreements on international ground on criteria for the education and training of conservators and restorers.

I was asked to cover the Scandinavian or the nordic area which means Denmark, Finland, Norway, Sweden and Iceland. These countries have a tradition for working together which reaches far back into history and this cooperation seems to gather ground within the frames of mutual agreements - among which there is an agreement on cooperation on cultural affairs. Within the profession of conservation and restoration there is also a tradition for contact and cooperation. This has been institutionalised first of all through the establishment of a northern society of restorers for more than 15 years ago, I think.

The society has until now consisted of 4 sections, one for Finland and one for each of the Scandinavian countries, Denmark, Norway and Sweden, but has just recently been enlarged with another section for Iceland. It is headed by a board with representatives for each country. This society MKF - "Nordisk Konservator Forbund" has officially appointed me to be their representative in this working group and in another so-called group of experts under The Nordic Council, whose function I shall return to later.

First I shall inform you about the progress of the plans for the establishment of a school in Denmark and very short remind you of the characteristics of that plan. I finished 3 years ago saying - "we are looking very much forward to the realization of these plans in the course of a few years, there is reason to hope. There is an extraordinary interest for conservation among young people in Denmark and there is an immense call for conservation from all the museums." This is still true. We have not come to a realisation of our plans yet, but

we are on the other side happy, when we consider the economical situation in Denmark today, which has brought many drastic cut-downs in the budgets of the state with it, to envisage the start of the school next year. However we have not come through without cut-downs too. If we compare the economical frame which was forecasted in the report of the Ministry of Cultural Affairs, in which the plans were first published, with what we have got, it shows, that the last is only a fraction of the first. Exactly what consequences this will have on the scheme of education is not known yet. When I now quote the ideas which lie behind the propositions for the set-up of the school, it must be in very general terms and referring to the report. The school will bring out conservation and restoration personnel for museums, libraries and archives. The pupils should be able to leave the school at a technician level or to study further with the aim of acquiring a degree compared to scientific or academic degrees at university level. There are entrance on a student exam basis and on a lower school education level too as well as special entrances for persons already fully qualified in certain crafts. It is as far as I know something new to suggest a school or at least to realise a school in which painting restorers, archaeological conservators and restorers of furniture, textiles, weapons, books and manuscripts and so on all should be taught their lessons under the same roof, but we find the experiment interesting and meaningful. We expect fruitful results and are also of the opinion of course that it should bring obvious advantages in educational respect.

The school is naturally divided into different lines and the possibilities of specialisation are legion. The education in natural sciences may within one of the lines be carried to such an extent that one in consequence may speak of a sort of engineer specialized within the field of conservation. We find that the time for completion of an education as technician should not exceed 3 years and for a conservation degree not necessarily more than 5 years. We have left behind us the thinking which can be met in some places in which namely educational periods of a double length are thought relevant, simply because existing traditional educations are being put on top of each other - you make a cabinetmaker first and then you turn him into a scientist. We need both the cabinetmaker and the scientist but not necessarily one man who is both. If anybody

... must be his own decision. Still we think that the men or women who is trained from the beginning with conservation in mind would fill a gap in the spectrum of education offered today. Of course a certain aftereducation is necessary from time to time as in all other expanding and developing occupations.

One of the consequences of the cut-down of our budget is, that we must turn our eyes out over the country borders. This brings me back to the working group or expert group put together under the auspices of the Secretary Office for Nordic Cultural Cooperation. This group came into being this year through a socialled member proposition in The Nordic Council, which is an organ on government level dealing with internordic affairs. The expressed purpose of the group is to investigate the possibilities for a coordination of the conservation education within the area of the nordic countries, that is - to seek a uniform definition of the necessary educational level, comment upon the eventual possibility of centralisation of parts of the education on to one or two centers - examine the question about bursaries for studies in a foreign country - nordic or not - and the collecting or preparing of educational material for common use in these countries. We are herewith approaching the questions which this working group has chosen for its work: Can common agreements be reached when dealing with criteria for and demands to different educations within the field of conservation, so that an education or degree acquired in one country would be recognized in another? Can propositions for decent salaries or decent employment conditions for persons trained in this way be worked out? Have they realistic chances to be followed? These are questions which are of great interest in many countries.

We do not promise our selves a easy job in the expert group of The Nordic Council, but it might be easier to approach the ultimate goal within a more narrow area than within a greater one. But we are laying much stress upon the exchanging of views which is going on within the frames of ICOM and this working group and we are looking forward to a more intense work in the group. Denmark has now made its ratification of the Rome Center and we should now be able to deal with these problems on an official level in cooperation with colleagues from other countries. We have noticed that the Rome Center in 1970

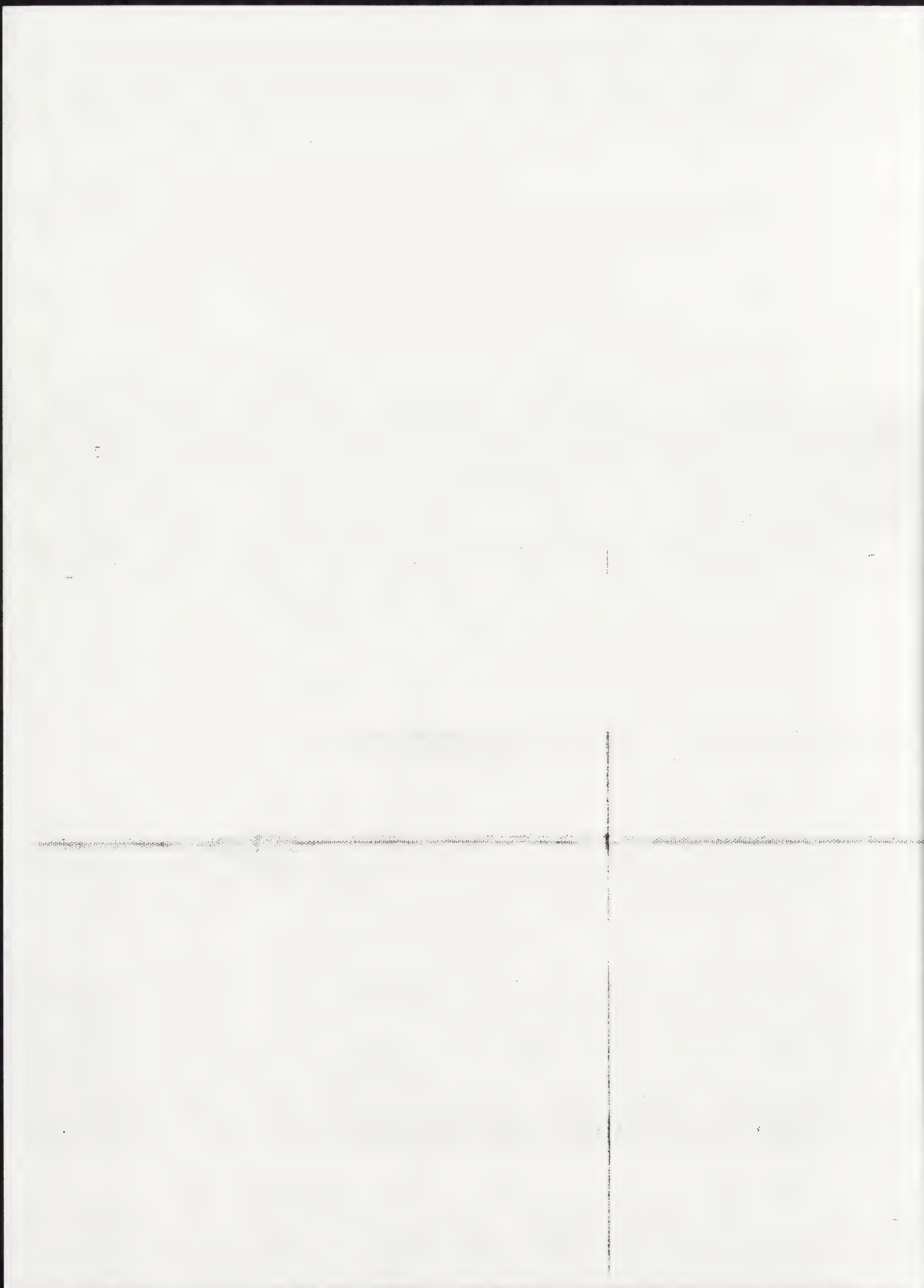
had a meeting calling upon a group of wellmerited schoolauthorities some of which are also members of this working group. As a result of the meeting a series of points on which there seemed to be general agreement were published in the ICON Nove vol. 23, no 4, dec. 1970. It is with satisfaction that we notice, that there in most parts are perfect agreement between our viewpoints and those put forward by the members of the meeting referred to. That promise a good climate for further discussions.

Let me say at last, that one should not deduct from what has been said here, that conservation has been a total uncultivated ground up till now in Scandinavia or the nordic countries. On the contrary it seems in the whole to have been all the more flourishing year after year ever since it started years back, although it has had its ups and downs. Yet we think that we are only at the beginning. Anyhow we are at the beginning of a new epoque in Denmark when the activities of the school are starting.

This has not been the place or the time for going into details about present activities in the nordic countries. Let me just say that educational activities are going on in different places but only on aftereducational basis.

And let me finally add, since I have spoken so much about myself; I am not the man who is going to be the head of the school in Copenhagen. That is my colleague, Steen Bjarnhof who is also present here in this house.

Knud Holm.





14/5

COMITE POUR LA CONSERVATION - MADRID: 2-3 OCTOBRE 1972

Groupe de travail: "Peinture du X^e siècle"

PROPOSITION POUR UNE METHODE DE DOCUMENTATION SUR LES TECHNIQUES DES ARTISTES ACTUELS.
DANIELE GIRAUDY

Les techniques de l'artiste se renouvellent puisqu'il est le témoin sensible d'un monde en pleine évolution, face auquel il traduit son inquiétude et sa joie, par les recherches visuelles dont il est le spécialiste. Ces recherches doivent s'exprimer dans le musée d'art contemporain et entraînent aussi une mutation de cette institution, où le conservateur devient le médiateur entre l'artiste et le public.

La présentation temporaire d'œuvres éphémères et périssables (environnement, gestes, concepts, body art etc...) peuvent être conservées par le film, la photographie, le magnétoscope, quand ni l'artiste, ni le musée ne veulent en conserver les traces.

L'acquisition pour les collections permanentes pose le problème de la conservation, de la restauration mais aussi celui de la consultation des artistes et de la documentation méthodique sur leur technique (différente de la documentation biographique ou esthétique).

Ces échantillons sont alors fournis par les fabricants de couleur (techniques traditionnelles), par les usines (nouveaux produits industriels), par les artistes eux-mêmes (fragments déjà élaborés, "recette" précise et mode d'emploi des supports, véhicules et outils).

Une documentation filmée rend compte, enfin, du processus créateur dans son déroulement. Elle est aussi établie en collaboration avec l'artiste.

Dans cette optique, quelques exemples sont proposés sur les artistes suivants: Pierre Alechinsky, César, Hans Hartung, Yves Klein, Victor Vasarely - films, photographies, échantillons du produit transformé par l'artiste, échantillons de ses différents supports, échantillons des couleurs fournies par les fabricants, échantillons des produits industriels fournis avec leur dossier technique par les usines.

Certes, ces "banques de données" posent le problème moral de l'accès à cette documentation qui doit être communiquée au restaurateur, mais protégée du faussaire. Elles permettent aussi de mieux connaître la structure technique entraîne d'art contemporain, et si chaque révolution technique entraîne un nouveau processus spirituel, elles nous aident à en comprendre l'évolution esthétique.

989/14







THE INTERNATIONAL COUNCIL OF MUSEUMS / /
COMMITTEE FOR CONSERVATION
WORKING GROUP: "TWENTIETH CENTURY PAINTING"

CONSEIL INTERNATIONAL DES MUSÉES
COMITÉ POUR LA CONSERVATION
GROUPE DE TRAVAIL: "PEINTURE DU XX^e SIECLE"

REUNION DU COMITE POUR LA CONSERVATION
MADRID: 2-8 OCTOBRE 1972

GROUPE DE TRAVAIL: "PEINTURE DU XX^e SIECLE"
COORDONNATEUR: P.CADORIN - BÂLE

ETUDE PRELIMINAIRE

APPLICATION DES PHENOMENES OPTIQUES A LA RES-
TAURATION DES PEINTURES.

SYLVAIN BRANS - PARIS

8981 20

Application des Phénomènes optiques à la Restauration des Peintures

Bien que le titre donné à cet exposé paraisse assez simple, il recouvre un domaine tellement vaste et complexe qu'il est impossible de le faire correctement dans le cadre étroit qui malheureusement s'impose ici. Nous avons opté pour un survol de quelques notions afin de montrer qu'il existe bien un problème intéressant, notamment pour les peintures dites du 20ème siècle, car les études sur la vision des couleurs et la colorimétrie peuvent permettre de suivre l'évolution d'un tableau à partir de sa définition première, de porter remède à certaines atteintes du temps par les agents atmosphériques polluants ou simplement par la lumière elle-même.

est
Le rôle du restaurateur, qui plus qu'un autre confronté à ces problèmes devient plus important dès l'instant où des moyens scientifiques sont à sa portée et dans le cas du 20ème siècle où il peut établir un dialogue avec l'artiste lui-même.

Une couche picturale représente l'un des 3 éléments de l'ensemble : (source d'éclairage, objet diffusant, oeil de l'observateur) sans lequel il n'est pas de couleur concevable.

La couche picturale, avec son support constitue un modulateur de lumière ou plus exactement d'énergie, laquelle se transforme en sensation de lumière et plus généralement en sensation de lumière colorée.

ne
Ceci constitue pas en soi une innovation, mais le fait de prendre parfaitement conscience de ces 3 éléments permet sans entrer dans la technique de l'artiste de lui apporter des éléments scientifiques susceptibles de lui permettre de mieux comprendre son processus de création; mais là où la

compréhension des phénomènes optiques apporte une aide substantielle, c'est dans la restauration des peintures.

L'apport de peinture obéit en effet, soit à des lois additives soit à des lois soustractives suivant la méthode employée et par conséquent elle dépend de la composition spectrale de la lumière d'éclairage et de la manière d'appliquer la peinture, soit par points en synthèse trichrome soit par couches en synthèse dite soustractive. La colorimétrie nous aide à comprendre l'importance relative de ces phénomènes et par conséquent est loin d'être superflue.

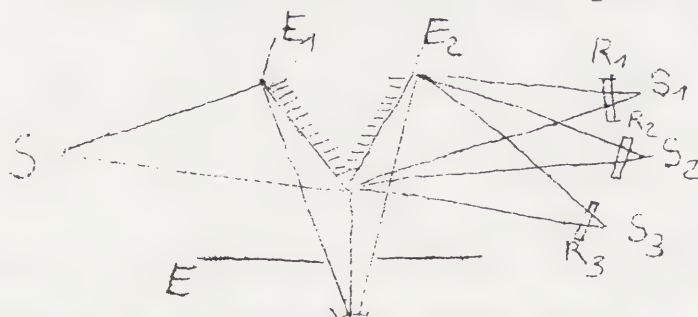
Nous donnerons ainsi dans cet exposé quelques notions de vision des couleurs et de colorimétrie appliquées aux problèmes de la restauration.

Trivariance visuelle.

Il est difficile sinon impossible de donner dans un exposé aussi bref que celui qui est attendu ici une description de l'ensemble des éléments qui ont conduit à cette réalité expérimentale : la trivariance visuelle.

Nous pouvons résumer cette propriété en disant sommairement qu'il est possible de reproduire par l'addition de trois lumières judicieusement choisies, l'aspect d'une lumière quelconque pourvu que celle-ci ne soit pas une lumière spectrale, c'est-à-dire une lumière telle que celles qui sont obtenues par la dispersion de la lumière blanche au moyen d'un prisme. En dehors de ces cas particuliers l'expérience prouve que toute lumière peut être reproduite visuellement par une synthèse additive.

Nous allons schématiser ceci par l'expérience suivante:



E^1 et E^2 sont deux écrans diffusants par exemple 2 cartons blancs faisant un coin entre eux. L'écran E^1 est éclairé par une source lumineuse S quelconque pourvu qu'elle ne soit pas monochromatique, c'est-à-dire formée d'une seule radiation ou si l'on veut d'une seule couleur pure.

L'écran E^2 est éclairé par trois sources lumineuses S^1, S^2, S^3 qui peuvent être ou non monochromatiques.

On prend la précaution de placer devant les pinceaux lumineux S^1, S^2, S^3 respectivement des appareils R^1, R^2, R^3 destinés à régler les intensités de ces lumières dans de larges proportions.

Résultat :

L'expérience prouve que l'oeil étant placé en O et recevant à travers un trou de l'écran E la lumière diffusée par E^1 et par E^2 peut obtenir une identité parfaite de l'aspect des écrans E^1 et E^2 par un réglage convenable des 3 lumières S^1, S^2, S^3 .

On dit qu'il a réalisé une équation colorimétrique que le physicien écrit :

$$S = S^1 + S^2 + S^3$$

Non seulement il y a identité d'aspect coloré, mais également identité de luminosité ou en parlant comme le physicien, de luminance.

Si l'on supprime l'une des sources il n'y aura jamais, à une exception près, possibilité d'obtenir cette égalisation.

D'autre part si l'on place une source S^4 du même côté que S^1, S^2, S^3 , il y aura alors un nombre considérable de possibilités de réaliser l'équation. On arrive ainsi à la conclusion suivante : 3 lumières sont nécessaires et suffisantes pour assurer la synthèse d'une lumière quelconque (ou presque)

Nous ne pouvons entrer dans le détail des théories colorimétriques et nous renvoyons au spécialiste auquel nous nous sommes adressé pour montrer qu'il y a des exceptions. En fait il n'y a "d'exceptions" que pour les lumières monochromatiques.

Mais une fois les lumières S^1 , S^2 , S^3 (dites primaires) choisies, on peut reproduire une très grande quantité de lumières à l'exclusion de certaines autres que l'on pourra d'ailleurs obtenir en changeant de primaires.

Ce qui se passe pour les lumières quand on fait une synthèse trichrome, se produit également pour les peintures, car un point coloré sur un tableau n'est pas autre chose qu'une source de lumière, mais ici la lumière est une source secondaire en ce sens qu'elle ne produit pas l'énergie elle-même, mais elle la renvoie vers l'oeil avec ses caractéristiques propres.

Quelles sont les caractéristiques d'une peinture?

La peinture est un matériau doué de propriétés physico-chimiques et ce qui nous intéresse ici ce sont les interactions matière-lumière.

Il nous faut donc connaître le comportement des matériaux utilisés vis-à-vis de la lumière qui les éclaire, mais aussi de l'oeil qui les regarde.

Le problème du restaurateur n'apparaît pas alors simple, mais il devient plus sûr dans la mesure où les lois de mélanges optiques sont mieux connues et il peut mieux orienter son travail pour aboutir à la retouche la plus appropriée.

Ainsi la couche picturale étant posée sur une préparation peut être analysée au moyen d'un appareil, le spectrophotomètre, qui va nous donner longueur d'onde par longueur d'onde la valeur de l'énergie renvoyée vers l'oeil de l'observateur.

L'ensemble des valeurs obtenues constitue la fiche d'identité de ce matériau, c'est-à-dire les caractéristiques intrinsèques de son comportement vis-à-vis de la lumière.

Nous ne pouvons pas entrer dans le développement des théories colorimétriques, mais nous pouvons dire qu'à partir des valeurs obtenues au spectrophotomètre, on peut déterminer quelle sera la couleur vue par un oeil normal (l'oeil moyen de la commission internationale de l'éclairage de 1931) sous un éclairage précisé à l'avance et par conséquent la repérer au moyen de trois nombres. C'est le rôle des techniques colorimétriques.

Bien que nous ne puissions dès maintenant préciser quelle sera l'importance de ces notions de colorimétrie pour l'avenir, nous pouvons affirmer que la synthèse trichrome faite par l'oeil ^{au} moyen de couleurs primaires possède ses propres lois qu'il nous est possible d'analyser et par conséquent de maîtriser en vue d'un travail déterminé.

Ce que nous savons avec certitude c'est que l'oeil travaille en synthèse trichrome au niveau physiologique et que par conséquent la restauration a beaucoup à attendre des études qui seront entreprises et poussées dans le domaine des phénomènes optiques liées à la vision des couleurs.

D'une part la colorimétrie des pigments permettra de repérer les couleurs les plus judicieuses à utiliser, d'autre part le restaurateur pourra déterminer quelle est la lumière la mieux adaptée à son travail, lumière qui devra d'ailleurs être de préférence identique à celle sous laquelle le tableau sera vu quand il sera exposé.

Là en effet se place un problème que nous ne pouvons entreprendre ici qui est celui du métamérisme, c'est-à-dire pour simplifier de la variation des couleurs en fonction de l'éclairage, variations qui ne se traduisent pas uniquement des différences mineures, mais qui peuvent faire perdre à un tableau toute sa réalité.

Si la restauration peut attendre beaucoup des études colorimétriques et des recherches sur la vision des couleurs, elle n'en a pas moins depuis longtemps utilisé les propriétés additives de la vision.

La restauration effectuée par nous, utilise largement la trivariance visuelle et constitue, s'il en était besoin, une preuve de la réalité de cette trivariance. En effet dans notre pratique quotidienne de la retouche, nous évaluons la complexité de la couleur qui se présente à nous, et nous plaçons sur la préparation les touches nécessaires qui constituent l'une des primaires de la synthèse qui va être effectuée par l'oeil, puis la deuxième primaire. Cela nous permet, par une approche très fine, de jouer avec la lumière du fond et de poursuivre la synthèse par addition d'une troisième primaire dont la quantité nous est immédiatement suggérée par l'évolution de la couleur obtenue.

Bien entendu quand les couleurs sont très pures, souvent deux composants sont suffisants pour réaliser la synthèse nécessaire et ceci par une approche très fine.

On peut conclure ce bref exposé en disant que les lois optiques que bien des peintre du 20ème siècle ont utilisées, en particulier celle des contrastes simultanés exposées par Chevreul quand elles sont bien comprises et bien utilisées, fournissent à la restauration des possibilités très grandes que nous utilisons chaque jour pour un travail de grande qualité au point de vue optique.





THE

PROGRESS OF

THE

ARTS AND

MANUFACTURES

IN

THE

UNITED STATES

OF AMERICA

FROM 1790 TO 1860

BY

JOHN R. HARRIS

OF THE

AMERICAN ANTHROPOLOGICAL ARCHIVES

NEW YORK

1860

ICOM Conservation Committee

Madrid 1972

Working Party on L I G H T I N G

Report by Coordinator:

GARRY THOMSON

National Gallery

London

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INTRODUCTION

Although a very great many museum directors remain comfortably ignorant of the illumination levels in their galleries and have not obtained the cheap equipment required to survey their situation, the size of this majority is now decreasing quite rapidly. Certain directors are energetically following up the need for conservation against damage by light.

Many delegates to this ICOM Conference will be continuing on to the Gulbenkian Museum in Lisbon. Whether they like the lighting there or not, they cannot but agree that a very great deal of care has been taken in the lighting control, with the need for conservation fully recognized.

Particularly notable also, in an ICOM context, is the opening in February 1972 of the partially completed Musée National des Arts et Traditions Populaires in Paris. This museum was conceived, planned, and directed until 1967 by George-Henri Rivière, founder-director of ICOM. It is not surprising, therefore, that lighting and air-conditioning are controlled to the highest conservation standards.

During the period since the last meeting of the ICOM Conservation Committee in Amsterdam two important reports on conservation and museum lighting have been published, in the U.K. and in France.

The first of these (Lighting of Art Galleries and Museums, Technical Report no. 14 of the Illuminating Engineering Society, York House, Westminster Bridge Road, London SE1. 1970) resulted from the initiative of Mr J.B. Harris, Lighting Adviser to the U.K. Department of the Environment, who chaired a mammoth series of committee meetings between representatives from museums, industry, the DOE and the Arts Council.

The second report ("La Lumière et la Protection des Objets et Specimens Exposées dans les Musées et Galleries d'Art", published in Lux no. 63, June 1971) was compiled by the French National Committee of ICOM, and owes much to the guidance of M. Gaymard. The two reports agree on basic conservation essentials, notably on the recommendation to eliminate ultraviolet radiation and on the adoption of the two-category 150/50 lux illumination level maximum.

Members of the ICOM Conservation Committee represented on these two committees were N.S. Brommelle and G. Thomson (U.K.) and L. Gaymard (France). There is naturally much discussion at ICOM meetings of action at an international level. Our own Working Party should perhaps consider whether the time is ripe for ICOM to issue international recommendations on control of museum lighting for conservation.

On balance it is my opinion that such a step would be premature, for the following reasons.

(1) In general, action can be taken at the museum, national or international level. There must usually have been some work at the museum level before national action becomes appropriate, and in this natural sequence international action comes last. However international action can be timely just as soon as national agreement has been established in one or two countries. ICOM is now in a position to give lighting advice based on the two reports mentioned above and in addition on a number of IIC publications. Until one or two more countries have committed themselves I think we need go no further.

(2) The 150/50 lux recommendations have been put forward as a basis for action while more knowledge of damage by light is acquired. They are not based on numerical formulae, but are an attempt to balance the need for good viewing against the need for good conservation. These levels can therefore be contested as soon as new information is presented concerning either (a) the relation between light levels and viewing, and (b) rates of damage by light in museums.

Mr Brommelle's contribution to this Working Party will clarify the first issue (a). My own interest during the last few years has been on (b), so that the next section of this report will be concerned with the measurement of colour change.

One need hardly stress that, in spite of the need for data, to ignore the control of light in museums where delicate material is on display would obviously be an irresponsible policy. Though we have much to learn on how quickly colours change, the fact that very many important works of art have been and are being damaged by light in museums is incontestable.

MEASUREMENT OF COLOUR CHANGE

Since any means of preventing colour changes on paintings is of very great importance it has been recognized for some time that it is desirable to record colour in such a way that changes can be measured (1, 2).

Up to now two things have deterred the setting up of such a programme: inadequacy of instrumentation, and the natural reluctance of any research worker to start an experiment knowing that he is unlikely to be present in the museum (or even on earth) when really useful data start coming in!

Nevertheless, in order to plan rational environmental control, we must know what colours are changing, how fast they are changing, and which factors in the environment affect this rate.

The colour at any point on a painting can be measured as a reflectance spectrum, which is a curve showing the proportion of light reflected at every wavelength through the visible spectrum (400-760 nanometres).

We plan at the National Gallery to set up two complementary systems of measurement: (a) measuring the complete spectrum at chosen points on paintings, and (b) recording the reflectance of the whole painting at 6 wavelengths spaced through the spectrum (400, 450, 500, 550, 600 and 650 nanometres). The first programme of development is under the control of Professor W.D. Wright of Imperial College. It would be inappropriate to describe this instrument here prior to publication by Professor Wright himself, other than to say that a reflectance spectrophotometer, designed for measuring colour change on small areas of paintings and recording the areas measured, is now in a late stage of development. The second method was devised at the National Gallery Laboratory and makes use of photographic densitometry. Errors inherent in each stage of the measurement have been estimated, but the method has not yet been put to practical use, though a programme should be under way by the end of the year. It is briefly described below.

Colour film records colour, but not very accurately and with a very low permanence. Originally colour prints were made from three black-and-white negatives, each exposed through one of three primary-colour filters. Essentially this is the method used here: exposures are made on black-and-white film, but with the three filters increased to six. Instead of using wide-band filters,

narrow-band interference filters are used, so that in effect the record consists of 6 negatives each recording the reflectance of the whole painting at one of the 6 wavelengths.

To convert the density at any point on one of these negatives to a reflectance value on the painting it is necessary to have an internal standard. This is provided by a set of 8 ceramic tiles, ranging in neutral tone from black to white. These are placed beneath the painting so that their images appear on every negative. These standard tiles are not expected to change over a century or so (which can be checked at any time with a spectrophotometer), and are used to plot the "characteristic curve" of the negative at the wavelength in question. This characteristic curve allows us to interpolate between the density steps provided by the tiles and so arrive at the reflectance value we need.

To carry this out at high accuracy certain errors have to be measured and allowed for, notably unevenness of illumination of the painting, variations in exposure, and variations in emulsion and development. There are also measurement errors.

After a period of 5 or 10 years another set of negatives is made under the same conditions, and comparisons must now be made between the "Old" and the "New" set.

To ensure that the same small area is being measured on both Old and New negatives, a comparison microscope is used in which the two negatives can be optically superimposed, after which the density of a chosen area on either Old or New can be read with a photomultiplier.

Fortunately we know that only certain pigments used in oil paintings are liable to change under exposure to light. We will therefore get a situation in which only certain areas of the painting will have changed, and the rest of the painting, notably the areas surrounding the change, can be used as a standard of comparison. Making use of this fact we can measure density change as a direct ratio between New and Old, and thereby reduce the error to less than $\frac{1}{2}\%$ (2 standard deviations) at 15% reflectance. The reason for this is that random variations in density over the negative no longer contribute to error, since only one part of the negative is used for measurement. Another advantage is that overall changes due to dirt or varnish discoloration are automatically cancelled out.

The accuracy of measurement can be regarded as adequate - once the areas which have changed have been identified. Unhappily the problem of finding small differences between negatives is not yet fully solved. There is little doubt that it can be solved, but at a greater cost than might be supposed.

Gross differences between two negatives (i.e. differences involving perhaps 25% of the reflectance value) can be spotted visually by such techniques as superimposing the two negatives illuminated by different colours, or illuminating alternately, or combining a negative and a positive.

However for detecting fine differences there seems to be no alternative to scanning both images electronically and combining the scans to obtain a difference signal. Why not do this on the original painting instead of on its photographic image, and store the record directly on magnetic tape, which can be handled by a computer? Such possibilities are currently being explored. If successful they should find conservation use, not only on paintings, but in all cases where some visible change is to be measured.

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Revised Ed. 1968, pp. 257-69. IIC, 608 Grand Buildings, Trafalgar Square,
London WC2.

MEASUREMENT OF CLIMATE INSIDE THE MUSEUM

Complementary to measuring colour change, the factors in the climate which cause the change must be investigated. We are only doing half the job if we measure change without also measuring the causes of the change.

Up to now the measurement of climate inside the museum has been limited to that needed for maintaining air-conditioning plus a few special once-for-all surveys. As far as I know no attempt has been made to link measurement of changes in actual valuable museum objects to concurrent measurement of the factors which cause the changes.

Probably most conservators feel that they would ^{get} cupboards full of data with no measurement of real deterioration at the end of it all. Of course this would be the happiest outcome. Yet there remains the matter of simple responsible housekeeping. As soon as we acknowledge that we are responsible for minimizing deterioration we recognize the need for a lot of information on the processes of change which are actually occurring in the museum.

There is no technical difficulty here, though some relevant factors in the atmosphere may yet have escaped our attention. The capital cost of the equipment described below is about \$9,000 and the cost of staff time is very low since the work is largely automatic.

The obvious parameters to measure are illumination level, wet and dry bulb temperature and air pollution. The measurement of these will be considered for an average exhibition room in a museum.

Illumination level

For each parameter we have to decide whether to measure periodically or continuously, whether to integrate or to measure at discrete moments in time. It is now possible to buy integrating light-meters, though this facility may be no less expensive than continuous recording of illumination level. The latter is preferable since it gives more information. Even though the light varies round the room, a survey will give us enough knowledge of this variation to need only one or perhaps two meters in the room for the continuous record. Exposures at any other part of the room can then be estimated.

Ideally any variation in the spectral energy distribution of the light should be on the record, especially variation in UV (e.g. electricians may forget to replace a UV filter). But the cost of this further elaboration may not be justified, since periodic checks of the proportion of UV in the illumination should suffice.

Temperature and humidity

Since hair hygrometers are notoriously subject to drift and direct electrical RH sensors to poisoning, the most trouble-free method is by measuring wet and dry bulb temperatures. We need only replace the two mercury thermometers by electrical thermometers. It is feasible to use a continuously aspirated wet bulb with a week's supply of distilled water, thus working on a weekly maintenance scheme.

Air Pollution

There are various alternatives here. Firstly, the U.K. Air Pollution Laboratory at Warren Spring has devised a semi-automatic method of measuring smoke and sulphur dioxide by aspirating air first through a filter paper and then through a solution of hydrogen peroxide. Both smoke and sulphur dioxide are recorded daily, but the instrument needs only to be visited once a week.

For sulphur dioxide only, the old lead peroxide cylinder, which can be left unattended for a month, may even now be most suitable. But there is some uncertainty in converting its readings into direct figures for concentration of sulphur dioxide in the air.

New developments are coming out fast. Sulphur dioxide can now be continuously and automatically monitored by flame photometry. On the other hand, unless one actually needs variations in sulphur dioxide through the day, use of this apparatus would be extravagant (cost about \$4,500).

Data logging

The information from all these sensors must be collected at a central point in a reasonably condensed form. Data logging involves automatically scanning the sensors in sequence at regular intervals and converting their readings into a form suitable for recording. The final output can be onto a pen-recorder (analogue output) or, digitized, either typed or put on tape. Information is more condensed on magnetic than punched tape, but the equipment is more expensive. Digital print-out in machine-readable form (magnetic or punched tape) is versatile, since this output can be processed automatically for integration etc. by computer, or even by programmable desk calculator. Considering the man-hours that would have to be spent reading and condensing reams of pen record or printed figures, punched tape is also probably the cheapest form of recording.

A data-logging package with punched-tape output consisting of two light-meters and two wet-and-dry-bulb hygrometers costs about \$9,000. Sulphur dioxide measurement cost is not included, but this would be small unless a continuous record was required.

It seems curious that while reams of data are recorded these days by all kinds of institutions and industries - data which may only be put to trivial use - museums with their great responsibilities, and even those with large purchase grants, have not got very far in checking whether or not their objects are safely housed.

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INVESTIGATIONS OF PHOTOCHEMICAL EFFECTS

by

The National Gallery of Art
Research Project

Robert L. Feller

A Report to the Sub-Committee on Lighting
ICOM Committee for Conservation
Madrid 1972

8981 46

By the National Gallery of Art Research Project
at the Mellon Institute of Science, Pittsburgh, Pa. (USA)

Deterioration of Protective Coatings: In the past, our laboratory has devoted considerable attention to the effects of light on picture varnishes, particularly the oxidation, linking together, and breaking apart of the molecules that comprise thermoplastic resins. The latest investigations on photochemical effects upon resins, to be reported at the IIC conference in Lisbon, will include data on the influence of turpentine, film thickness, oxygen, and oxidation inhibitors upon the phenomenon of crosslinking.¹ During Dr. Stolow's session on Solvents and Solvent Action, we will also report on the "strength" of solvent required to remove coatings that have been aged by exposure under glass to fluorescent and xenon-arc lamplight.²

HgS	\rightleftharpoons	HgS	\rightarrow	HgS
Cinnabar	reversible	Darkened State 1		Darkened State 2 (Metacinnabar?)

in which we find that the normally slow reversal of Darkened State 1 to the red color of cinnabar can be hastened by gentle heating.

New Pigments and Dyes: Alizarin possesses a degree of lightfastness of only about 4 to 5 when diluted with white pigments. We've investigated the possible benefit of ultraviolet absorbers and oxidation inhibitors either added to alizarin paint or to a protective varnish. The latter proved to be the most effective way to reduce fading (Table 1). Evaluation tests on new light-stable pigments have recently included so-called "silica-coated" titanium dioxide, lead chromate yellows, and molybdate oranges.⁴ Silica-coated molybdate orange, exposed under glass on the roof for one year, showed a net color change (ΔE MacAdam) of only 2.9 compared to a change of 32.3 for the ordinary uncoated variety. In the search for standards of highly durable paints, we find that the best, when exposed outdoors for one year in Florida, are frequently observed to change no more than about 5 MacAdam units in color (See V. C. Vesce, "Exposure Studies of Organic Pigments in Paint Systems", Official Digest, December 1959, Part 2). In the above tests, for example, a silica-coated chrome yellow changed only 3.4 MacAdam units, and two nickel titanate yellows, also being evaluated, changed only 1.2 and 1.8 units after one year under glass on the roof in Pittsburgh facing 45° south.

On behalf of the American Artists' Professional League we've verified the high degree of lightfastness of a number of organic "toners" that have been introduced in artists' paints in recent years.⁵ Only materials having a lightfastness better than BS1006:1971 class 6+ are considered. A search is also being made for the most lightfast dyes soluble in water and

organic-solvents.⁶ Soluble colorants rarely exhibit a degree of light-fastness greater than BS1006:1971 class 5+ but a water-soluble phthalocyanine blue, BASF Luratin Supra Turquoise Blue GL, is of special interest to us and an azo yellow, GAF's Azosol Yellow RCA (CI Solvent Yellow 13) conveniently serves as a standard of minimum tolerable lightfastness.⁶

Discoloration of Varnish: To conclude our studies of discoloration, we've made some preliminary tests on the color of varnishes and investigated the long-held view that light will bleach certain natural resins. The only bleaching noticed in the tests reported in Table 2 is the case of an old dammar, and also a coating of Elvacite® 2046 (copolymer of butyl methacrylates); in both perhaps remnants of the solvent were bleached.

Theoretical Considerations: Along with investigations of practical problems of photochemistry, consideration is being given to theoretical aspects, particularly with respect to a standard way of reporting the loss of solubility through crosslinking and observing the effect of ^{anti}~~auto~~oxidants upon this phenomenon. Polybutylmethacrylate provides a convenient reference polymer for crosslinking studies.¹

Consideration of autoxidation theory has lead us ^{to}~~the~~ search for evidences of induction time in various deterioration processes. Thus far we have found examples of induction time in data on embrittlement, discoloration, fading, loss of tensile strength, oxidation and crosslinking.⁷ The importance of these considerations to preservation science is that we are led to understand that the most effective protective measures that may be employed during the induction stage of thermal or photochemical oxidation are bound to be different than those needed during the "steady state" stage

4.
of oxidation or at the time past this stage when oxidation is no longer proceeding at its maximum rate. Breaking down an oxidation process into initiation, propagation and termination steps, we find that our use of antioxidants to retard crosslinking has influenced primarily the initiation or induction stage and has had much less effect on the propagation reactions, although some ^{anti}~~auto~~oxidant systems do induce a degree of chain breaking.¹

By analyzing oxidative deterioration into induction, maximum-rate or steady-state, and declining-rate stages, or the initiation, propagation and termination steps, we should be able to make significant advances in attacking problems of preservation and deterioration. This analysis, for example, teaches us that exposure to light shortens the induction time or the time needed to reach the maximum rate of oxidation in hydroperoxide processes, but it usually does not influence the essential propagation reactions or the maximum rate of absorption of oxygen. Such an analysis reminds us to reconsider the thermal processes of deterioration as well as photochemical, for exposure to light involves primarily the initiation step. Lowering the temperature, and the humidity, and employment of certain types of antioxidants are the avenues by which we may be able to influence the propagation steps in deterioration as we pursue these investigations in the future.

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TABLE 1

Fading of Treated and Varnished Alizarin/Titanium White Paints
Exposed Under Glass On Roof

<u>Paint Vehicle</u>	<u>Varnish</u>	<u>Rate of Fading</u>
Elvacite® 2046	None (control)	0.33
Elvacite® 2046	None (2% T328 mixed in the paint) *	0.31
Elvacite® 2046	None (1% T328, 1.5% LTDP mixed in)	0.30
Paraloid® B-72	None (control)	0.29
Paraloid® B-72	Elvacite 2046 + 1% T328, 1.5% LTDP	0.22
Paraloid® B-72	Elvacite 2046 + 2% T328	0.17

* T328 is Geigy Tinuvin 328 ultraviolet absorber; LTDP is dilauryl thiodipropionate antioxidant.

TABLE 2

Effect of Exposure on Color of Varnishes Observed Over Barium White
(Color Difference Relative to the Slightly Greenish Glass Upon Which They Were Coated)

	Original	After 140 Days Exposure	Approximate
	ΔE	ΔE	Thickness Mils
Paraloid® B-72	0.10	0.29	1.5
Poly(vinylacetate) Vinac® B-15	0.11	0.57	1.5
Paraloid® 67	0.34	0.53	1.5
Elvacite® 2046	0.30	0.16	1.5
Elvacite® 2046 + 2% T328	0.31	0.59	1.5
"Just Perceptible" Color, Approx.	(0.60)	(0.60)	
Pale Dammar A	0.60	5.13	3
Old Dammar B	1.98	5.13	3
Lab. Prep. of Dammar + Turp.	3.91	6.42	2.5
Picture Mastic A	3.72	5.88	4
Mastic B	4.48	7.32	3.5
Lab. Prep. of Mastic + Turp.	5.21	6.87	3

Samples exposed to about 2,500,000 footcandle hours of exposure to daylight fluorescent lamplight in a room maintained at 70°F, 50% R.H. In this time, the BSI006:1971 blue wool fading standards faded as follows: No. 1 to geometric grey scale contrast 0.3: No. 2 to 0.8, No. 3 to 1.8, No. 4 to 2.9, No. 5 to 4.0. Color Difference based on Hunter L, a and b, Equations 32 and 32b in Deane, B. Judd, "Color in Business, Science and Industry," J. Wiley, 1959, p. 260.





Visual Performance with Limited Illuminance

N S BROMMELLE

The difficulties of interpreting what is presented to the eye are described by lighting specialists as "the visual task". The museum visual task is of the highest difficulty in some respects but not in others. Speed of response to the visual stimuli is of negligible importance and the visual task is ordinarily immobile. The object can often be "appreciated" at a range of levels of task difficulty a, b, c, d according to the experience and informational requirements of the observer. It is possible to obtain satisfaction from the museum visual task even when it is incomplete, by stopping at a particular point in the scale, say c, from inexperience or lack of interest. There is also a terminal point in the range a, b, c, d beyond which the observer need not go unless he is a technical specialist. For objects of art this point is the limit of significant visual detail intended by the artist. To this can be added, especially in objects of applied art the textures inherent in the materials and revealed by their treatment by the craftsman. This point may be a matter of interpretation by the observer. For example the artist may have wished tool marks to be seen, or not, or may have been indifferent. In later interpretation they may be considered to enhance the aesthetic value, or to be a characteristic feature of the artist's work, and the curator is required to provide the conditions in which they can be seen. The visual task for objects of historical and archaeological interest may, as far as it does not include an artistic component, be different and, for display as distinct from research, needs only to be lighted sufficiently to reveal features which illustrate the didactic purpose of the exhibition.

The above requirements, though not necessarily calling for the highest level of visual performance, may fall short of fulfilment, not only by the limited light levels required for conservation but also by the factors of presentation. Dramatic lighting of a three-dimensional object may require sacrifice of visibility of surface detail; a wallpaper of high reflectance, historically accurate in a designed interior may, for reasons of adaptation, make it impossible to see the decorative detail of a dark costume. It is the purpose of this preliminary note to examine to what extent performance is reduced by limitation of light and to refer briefly to methods of counter-acting the effects, i.e. to achieve optimum performance at a given level.

The inspection of a single object involves its angle of subtense with the eye and also that of its local background. Only in special circumstances, as with a tapestry or large painting is the angle of subtense so large that the object fills the field of view. Consequently the luminance and colour attributes of the background combine with those of the object in fixing the adaptation level of the eye and the visual task itself. The visual attributes of the object are its contour, its form in two or three dimensions and its surface features which, for the present purpose consist of patches of various sizes diminishing to fine detail of both pattern and texture in a range of luminance and colour. The museum presentation can vary in complexity from large flat objects in which problems of local and general surround are virtually absent, to a miscellany, in one island showcase of three dimensional objects of widely differing surface textures and detail, with a complex background of local areas of differing luminances consisting of lights, reflections from windows, lamps, other showcases and people. The visual performance consists in the ability with which, under such comparatively simple or complex conditions, the attributes outlined above can be "read" (to use an ambiguous expression common in England) i.e. apprehended, at the level a, b, c, d etc. required.

Experimental Evidence

The experimental data from scientific research have to be examined from the point of view of their relevance to the illuminance levels of museum display which ordinarily cover the range 0 - 1000 lux, with intermediate proposed maxima of 50 and 150 for highly and less highly vulnerable objects, following Thomson's recommendations (1). To estimate light levels used in particular experiments, the following approximate conversions can be used:

Luminance (L) is usually expressed in candela.(cd) per cm^2 . Conversion to apostilb, the luminance of a perfect diffuser emitting 1 lumen per metre 2 , enables the results of an experiment to be referred to lux the unit of illuminance ($1 \text{ lumen}/\text{m}^2$), bearing in mind that the luminance of a reflecting surface is the product of the illuminance and the luminous reflectance. $1 \text{ apostilb} = 0.318 \text{ candela}/\text{m}^2$. A unit of luminance also used in photometric measurements is the troland, corresponding to an illuminance producing a luminance of $1 \text{ cd}/\text{m}^2$ through a pupil of 1mm^2 . / apostilb is equivalent to about 0.8 trolands so that the order of figures is about the same, for the purpose of estimating at a glance whether a particular set of figures is relevant to the museum situation. For example a well known experiment by Purdy demonstrates the wavelength shift produced by the Bezold-Brücke Effect in changing the illuminance from 10 to 1000 trolands. This is obviously within the museum range but it is easy to show from the wavelength-difference sensitivity curve of Wright and Pitt that the result is close to the threshold of discrimination and is unlikely to be recognised in the luminance ranges of the museum, in a practical visual situation. Speaking generally, small effects, distinguishable in controlled laboratory experiments may well not be observed in the practical museum task, particularly when conducted at low angles of subtense as a consequence of complicated factors of ocular adjustment and compensations.

In the outline of the museum task, above, the contour of the object need not be discussed in the present context. It can be emphasised or minimised at will by changing the magnitude of object/surround luminances, though noting that these changes may alter the level of adaptation thereby influencing the perception of visual detail in the object.

The most important part of the museum task is the perception of luminance differences in the object, considering, first, the achromatic aspects. The ratio dL/L where L is the luminance of a surface and $L + dL$ that of a surface which is just perceptibly brighter, is assumed to be constant according to Weber's Law. In fact, under conditions of adaptation, i.e. in which the eye is adapted to L the Weber fraction continuously decreases as L increases, to an asymptotic limit. For a field with an angular diameter of several degrees an analysis by Moon and Spencer (2) shows that the relationship, in cd/m^2 can be given as $dL = C (0.456 + \sqrt{L})^2$

This leads to the possibility of marking a point in the increase of L at which the limit has been reached within 5%. This, from Le Grand (3) is $340 \text{ cd}/\text{m}^2$ (1070 apostilb).

The improvement in visual performance with increase in luminance, and, in fact with increase in illuminance level, of which the changes in dL/L are the most fundamental expression, within the generally useful range of practical indoor activity is the central feature of visual task studies. It is a matter of indisputable common experience that the appraisal of an object (as in the museum task) and the performance of operations requiring light are more efficiently done at a higher than a lower illuminance. "Never judge women and linen by candlelight". This, ignoring the psychological effects of colour temperature is the expression of the high value of dL/L at low luminance levels combined with the effect of a low adaptation level on lightness gradation.

In this case there is the complicating factor of low background luminance which distorts the Munsell grey scale so that the lower steps are spread out and the higher ones bunched up, according to Judd. (4). Fig.1. The simplification of tonalities brought about by these effects is used in the representation of candlelight scenes by Georges de La Tour and Houthorst.

Recent work, and that of earlier investigations, on a range of visual tasks, has been reduced by various means to a relationship between L and the reciprocal of dL/L (the contrast sensitivity) by the Committee on Visual Performance (E.1.4.2.) of the Commission International de l'Eclairage (C.I.E.) in Report No.18. In the terminology of the Report, the Contrast Sensitivity (CS) is the inverse of the value of dL/L required to bring a task to a specified level of visibility or visual performance. It is specified in fact in terms of Relative Contrast Sensitivity RCS, a percentage of the CS in terms of the maximum possible value at $10,000 \text{ cd/m}^2$, it having been found experimentally that the change with luminance L is small above $5,000 \text{ cd/m}^2$ (Fig.2). Its characteristic is that ~~of~~ increase in RCS per unit increase in luminance is large at low levels of luminance but becomes progressively smaller as the luminance is increased. The figures refer to Reference Lighting Conditions of diffuse illumination and a visual field of uniform luminance. Whilst the function is somewhat variable depending upon the physical characteristics of the task, the conditions of observation and the individual observer, the Committee considers that the standard function tabulated in the Report provides a reasonable approximation for many tasks, in the range $1-10,000 \text{ cd/m}^2$.

In the report this basic curve is plotted as $\log \text{RCS}$ as a percentage against $\log L$ (Fig.2) but I find that it transforms to a straight line over the whole of the museum range and beyond, when RCS itself is plotted against $\log L$. (Fig.3). This observation may or may not be of theoretical significance but it is useful.

The sets of data used to derive this function were of two kinds. The first, from controlled laboratory tests, mainly by Blackwell and his colleagues in the USA were generally the detection of the presence of a luminous disc of diameter 4 minutes exposed for one-fifth second duration. In other tests, more obviously related to the museum task the standard patterns of visual acuity experiments were used, involving the resolution of the Landolt ring (a ring of specified thickness-diameter ratio with a specified gap), parallel bars, gratings and dot patterns, all exposed for one-fifth second. It was found that both detection and resolution results fell on the curve.

These tests were under controlled conditions of ocular adjustment. The second class of experiments included more realistic tasks in which normal ocular movements were possible, mainly by Weston in the UK. The results required adjustment from the task contrast which was of necessity supraliminal, to that of the visibility threshold. The results fitted well, down to about 10 cd/m^2 , but below this gave less reduction in RCS with reduction in L than the curve predicted.

The results of work tasks by other investigators showed a greater RCS decrease than the curve predicted. Nevertheless this standard function was considered to be a valuable reference standard.

The CIE report indicates from the work of Blackwell et al. a significant lowering of contrast sensitivity for observers above age 50. It would be tempting to adduce that older museum visitors needed more light than younger ones to see the significant features of an object but in the museum task the factor of speed of vision is absent whereas it is present in all the data used by the CIE. However, it will be necessary in the museum experiments to test the significance of age as a variable in the static experiment. The CIE Report notes the need for more data on different national populations. It is interesting to note, en passant, that other workers have observed changes in the absolute threshold dL when $L=0$, in observers over age 50 (3 p.245).

To the extent that this standard plot has relevance to the museum task and it is likely that it has in a general way, various interesting conclusions can be drawn. Even with

a curatorial staff, as at the Victoria and Albert Museum, keenly conscious of the damaging effect of light on some objects, the conditions of display often seem to call for light levels greater than those proposed by Thomson (1) and accepted by the IES in its report, "The Lighting of Museums and Art Galleries", instead of keeping to the two proposed maxima 50 and 150 lux they seem to prefer the range 150 to 300 lux and particularly the region of 200.

Let us consider the effect of doubling the Thomson figures, thereby doubling the damage to the objects. Raising the illuminance from 50 to 100 lux on light objects raises the RCS from 42 to 50%, a proportional improvement of only 19%. Doubling from 150 to 300 (RCS 55 to 62%) yields only 12%. It can hardly be said that the game is worth the candle! For dark objects, e.g. reducing the Munsell value from 10 to 3 with a corresponding luminous reflectance of 0.66 (5) the RCS is reduced from 42 to 14% at a light level of 50 lux while with a light level of 100 lux the RCS is reduced to 19%, i.e. a proportional improvement on 14% of 37%, better than with light colours but still far from 100%.

The conclusion to be drawn from these rough calculations is that, bearing in mind that the damage is doubled by doubling the illuminance, the improvement in performance obtained by doubling the illuminance is trivial compared with the great differences in performance between darker and lighter visual tasks, unless, for some reason the detail on dark objects is of exceptional significance.

If it were, then bringing the RCS at Munsell value 3 back to the figure at Munsell 10 at light level 50 lux would require a light level of about 700 lux.

It would appear that rather than attempting to improve the visual performance by increasing the light level at a disproportionate cost to the object it is better to concentrate on choosing an appropriate luminous reflectance and chromaticity for the background in cases where background plays an effective part in adaptation. Also, a relevant and overlapping factor, the presence of disability glare sources should be detected and eliminated. Neither of these subjects will be discussed here.

It should be noted that the above figures refer to situations in which the eye is adapted to the particular luminance level whether high or low. A typical museum task however is of detail within a dark patch against a light background which provides the adaptation luminance. There appears to be little data on this important matter apart from studies of discomfort glare. Visual acuity tests by Lythgoe (6) (Fig.4) using Landolt rings show that visual acuity increases with increase in the surround (and presumably adapting luminance) to a maximum close to the task luminance after which performance falls off sharply.

The CIE Report is intended to provide a basis both for assessing the performance of lighting installations, and for aiding the design of installations required to provide a particular level of visual performance.

The RCS/L curve which has been discussed above refers to a standard reference lighting of diffuse illumination and a visual field of uniform luminance (the Reference Lighting Conditions). The additional effects of directional lighting and of spectral composition are combined in a multiplying factor, the Contrast Rendering Factor CRF which may be less or greater than 1, depending on whether visual performance is improved or not in comparison with the reference system which is one of monochromatic diffuse lighting. The effective RCS is then $RCS \times CRF$ at each luminance level.

Controlled experimental work on this factor is not sufficiently extensive to provide a firm basis either for the measurement of CRF or its prediction with particular installation designs. The Museum task which is particularly complex in this respect is not clarified by the comparatively vague treatment of the subject in the CIE Report. Non-diffuse lighting is essential for a variety of museum tasks, both for the revelation of form and protrusive detail and for providing specular reflections, the subjective

apprehension of which is a guide to the discrimination of surface texture and hence of the nature of the reflecting surfaces. This subjective analysis is probably based on the spread of fringe reflections around the major reflection angle an analysis, in effect, from experience, of surface detail below the limit of visible resolution of detail. The question arises whether this particular aspect of CRF itself varies with L. In other words is the discrimination of fine surface texture as revealed by surface reflection quality enhanced or not by an increase in light illuminance?

Experimental work on the effect of colour on visual performance is meagre. The effect of field size, chromatic surroundings and luminance level on colour discrimination ellipsoids in the chromaticity diagram have been studied by Brown (7). With a 2° field and dark surround, chromaticity discrimination remains fairly constant for a considerable range of luminance above about 1ft lambert and up to 10ft lambert. Below this the cross-sections of the discrimination ellipsoids become larger (i.e. discrimination falls off). This suggests that light levels as low as 50 lux on a dark object might show less colour detail than higher levels. According to Thomson and Trezona and also Weale (5) ~~how-~~
~~ever~~ there is a progressive deterioration in colour discrimination as the luminance is lowered.

A relevant factor in the present study (of the effect of light levels on the appearance of museum objects) is that changes in luminance in conditions of adaptation produce large changes in colour saturation (chromaticness) for colours of the same chromaticity. In other words, with an adapted eye more brightly lighted objects look more colourful. This is a factor of common experience. Hunt (8) provides an explanation for this in a consideration of possible effects of increasing adaptation on the neural mechanism, which results in sharpening the spectral response curves of the three retinal receptors at high adaptations. The data of Hunt, plotted in the CIE diagram show that, with reduced luminance the decrease in chromaticness is non linear, the implication being that, in a multicoloured object the colours change relatively to each other.

Hunt's experiments were carried out with foveal vision using a white surround of the same luminance as the test stimulus. The retinal illuminance covered zero to 6300 trolands and thus included the museum range. The consequence of this effect for the museum visual task must be that lowered illumination for reasons of conservation, and raised illuminance for reasons of display may both alter the chromaticity to an extent that could or should be unacceptable from being too "drab" or from being too colourful, and some distinction has to be drawn between objects deliberately coloured by the artist and those whose colour derives from natural materials. In the former the light level if chosen solely for aesthetic reasons must be a matter of judgment in the absence of the artist; with the latter a lower light level may be regretted as not "bringing out" the colours whereas a much higher illuminance and adaptation as in a strongly lighted general display seems to enhance for example the colour of furniture unnaturally, the effect being, presumably due to the phenomena investigated by Hunt and certainly not to the phenomenon of "aperture colours" in which a coloured surface is brightly lighted in conditions of low adaptation.

The present subject is mainly that of the effect of alterations in general illuminance levels, and therefore various matters of vital importance to display, particularly of coloured contrast, colour adaptation and the effect of colour and luminance of the surround on such tasks as visual acuity will not be discussed. There are numerous questions to be answered in the museum field with regard to the problem of viewing the object, on which no systematic work has been done, and the problems are generally solved by the curator and display expert by empirical methods. Work on the effect of backgrounds of varying luminance and chromaticity on such visual tasks as acuity and sensitivity to small colour differences has been done by Lythgoe, Schonfelder Brown, Foxell and Stevens (6) and, more recently Eastman (9). This work is relevant and applicable to museum problems.

An experiment of close relevance both to the effect of illuminance level and that of background is planned at the Victoria and Albert Museum. In this experiment actual museum objects will be presented to experienced curatorial observers who will be required

to adapt to steps of illuminance level and record the points below which detail of significance to the specialised observer can no longer be seen. Illumination variables will be: sources of high and low correlated colour temperatures and two arrangements of lighting geometry, viz. diffuse illumination and the same with an added directional component at a fixed angle with the line of sight. Task variables will be, using the Munsell terms, a range of backgrounds consisting of five chosen hues (N, R, G, B, Y) with combinations of moderately high and moderately low levels of hue, value and chroma. The amount of time available to museum personnel will make it necessary to condense the experiment to some extent in view of the number of permutations of the above variables. A study of such factors as disability glare and transient adaptation (from eye movements) are not at present in the programme. A first series of experiments will be limited to a study of the more light sensitive objects, which, apart from costume are mostly two-dimensional.

Note: The CIE Report No.19 on Visual Performance is not yet in circulation and I have used a draft copy kindly lent to me by Dr J B Collins of the Building Research Station (UK). Dr Collins informs me that he himself is about to embark on experiments on the museum visual task and I hope to effect a collaboration. Whilst I have not discussed details yet with Dr Collins it seems reasonable that some attempt should be made to adapt the experiments to the proposed systematisation outlined in Report No.19 which I have not discussed here in detail, nor has Dr Collins yet seen the above preliminary notes.

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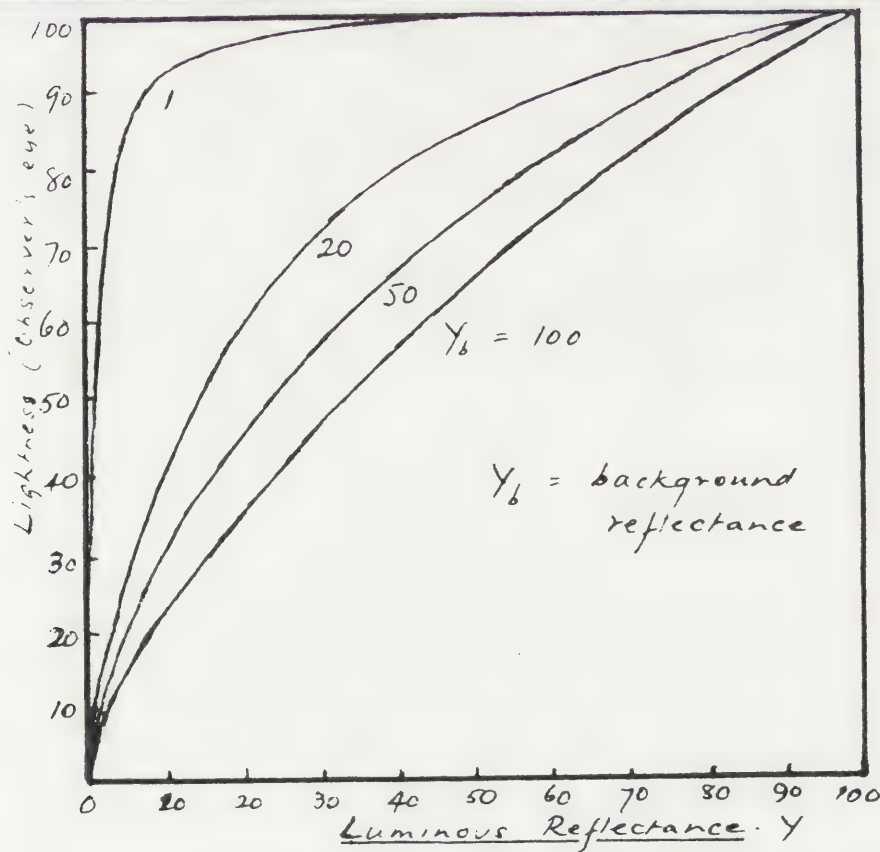


Figure 1. Effect of Adaptive State of Observer's Eye

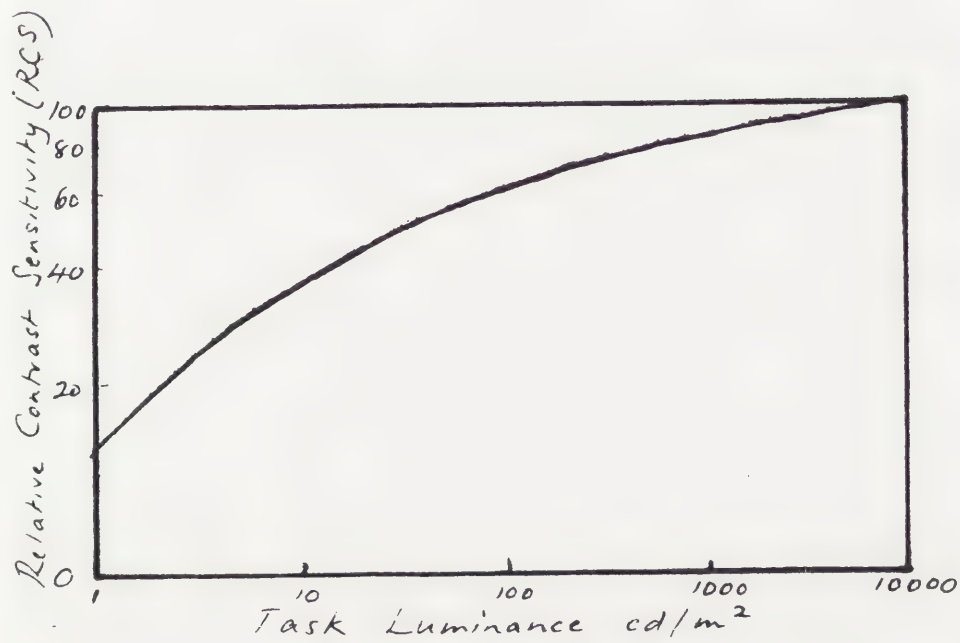


Figure 2. RCS plotted logarithmically

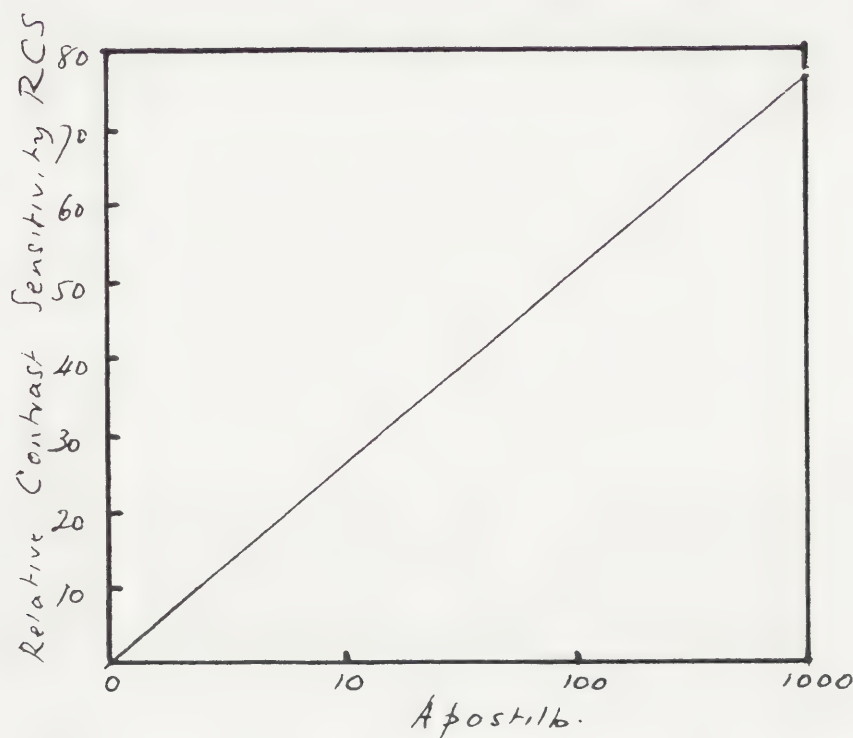


Figure 3. With RCS plotted linearly

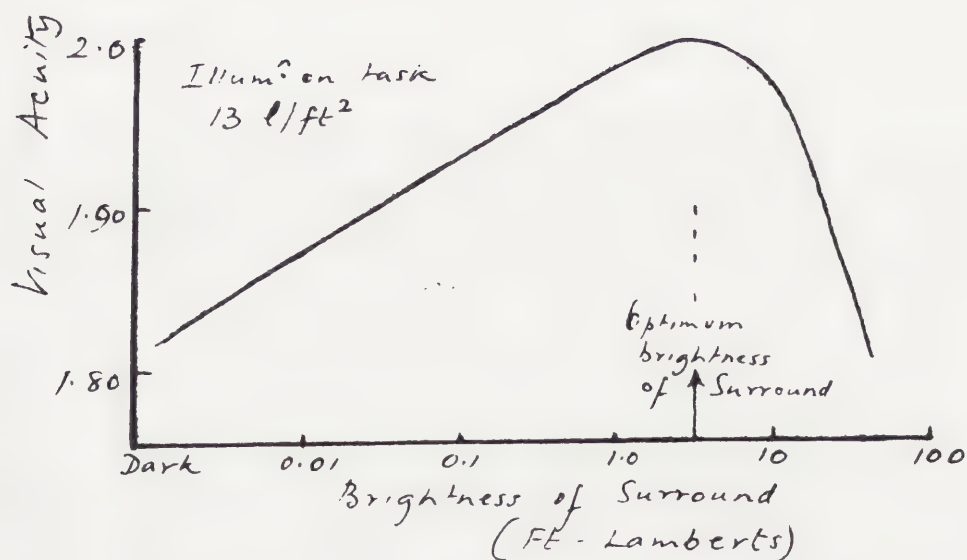


Figure 4. Effect of increasing surround brightness at constant task illuminance.



the 1990s, the number of countries with a democratic government rose from 40 to 65, and the number of countries with a democratic government that had been elected in a free election rose from 20 to 35. The number of countries with a democratic government that had been elected in a free election and had a free press rose from 10 to 15. The number of countries with a democratic government that had been elected in a free election and had a free press and a free market rose from 5 to 10.

These figures show that the number of countries with a democratic government has increased significantly in the 1990s. This is a positive sign for the future of democracy. However, it is important to note that the number of countries with a democratic government that has been elected in a free election and has a free press and a free market is still relatively small. This suggests that there is still a long way to go before democracy is firmly established in most countries.

One of the reasons for the increase in the number of countries with a democratic government is the end of the Cold War. This led to a decline in the number of countries with a communist government. At the same time, there was a rise in the number of countries with a democratic government. This was due to a combination of factors, including the collapse of the Soviet Union and the end of the Vietnam War.

Another reason for the increase in the number of countries with a democratic government is the rise of the middle class in many developing countries. This has led to a demand for more democratic governance. In addition, there has been a growing awareness of the benefits of democracy, such as economic growth and social stability.

Despite these positive trends, there are still many challenges facing democracy. One of the biggest challenges is the rise of authoritarianism in some countries. This is a threat to the future of democracy. However, there are also many reasons to be optimistic about the future of democracy. The number of countries with a democratic government is still growing, and there are many more countries that are on the path to becoming democracies.

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Wayward
The latest French achievements
in the field of museum lighting

(a paper to be distributed to the ICOM Madrid meeting, october 1972)

The French document on museum lighting

This document, entitled " Light and protection of objects and specimens displayed in museums and art galleries ", has been issued in Autumn 1971 .

Its first chapter gives an account of the properties of light and of the different kinds of radiations emitted by the various luminous sources . It then exposes what kinds of damages can be caused to the different sensitive materials by infra-red, visible or ultra-violet radiations . Next, it gives detailed indications or rules and precautions to be observed, and also detailed recipes to be followed, to provide in each case and for each kind of objects a convenient and innocuous illumination . This part of the document is elucidated and illustrated by a lot of plans and sketches, a number of which were taken from the English Illuminating Engineering Society's Technical Report on Lighting of art galleries and museums .

In its last part, the French report brings forward a number of examples and monographies of French and foreign installations .

a It is anticipated to have this document translated into English in not too distant future .

The latest french achievements

1°) The " Grande Galerie " in the Louvre

This gallery is extraordinarily oversize :	length	288 meters
	width	9, 50 m.
	Height under translucent ceiling	10, 50 m.

Its long side being East-West, it has been necessary to provide in day-time a powerful illumination of the southern side, which faces north . On the other hand, the night lighting is of the same level on both long sides of the gallery .

For aesthetic reasons, it has been concluded that absolutely no lighting material should be visible in the gallery : the whole installation has thus been placed between the roof and the translucent ceiling .

This installation is made of :

- 4000 " Blanc brillant de luxe " 1m, 50 long, 65 watts fluorescent tubes .
- 2000 " Lumière du jour de luxe " 1m, 50 long, 65 watts fluorescent tubes .

The resulting light is quite similar to daylight, and gives a very satisfactory colour rendering .

Dimmers allow :

- a) by day, when the sky is overcast, to equilibrate the lighting levels on both South and North walls .
- b) by night, to provide the translucent ceiling with a uniform brightness, in order to have, on the walls, an average illumination of 250 watts initial, which has come down to 150 - 200 through aging .

.../...







Madrid: October 2-8, 1972

Wiesław Domasłowski - Janusz Lehman (Coordinateurs)

LES RECHERCHES SUR LA TECHNOLOGIE DES MASTICS
EPOXYDES POUR COMPLEMENT DES DEGATS DANS LES
PIERRES QUI ONT SUBI DES ALTERATIONS

Le comblement des dégâts, la reconstruction des pertes et le comblement des crevasses et des trous dans la pierre altérée présentent un des problèmes importants dans la conservation des monuments en pierre. Ce problème n'est pas jusqu'à maintenant résolu par les méthodes généralement utilisées. Les matériaux et aussi les modes d'emploi éveillent souvent toutes réserves. Le comblement des pertes par la méthode nommée "rapiêçage" est contradictoire à cause de la nécessité d'agrandir les dimensions des crevasses et des trous afin de les former en espaces "géométrisés" et par la raison qu'on ne peut pas atteindre l'uniformité de la rapiêçure et de la pierre de l'objet; les pièces de la pierre neuve mise dans la pierre endommagée se séparent par la couleur plus claire et par l'encadrement du ciment utilisé au but de fixer la pièce ajoutée. Très souvent l'influence défavorable du voisinage entre la pierre et le ciment entraîne l'altération.

On peut obtenir des résultats plus favorables en utilisant les mortiers; là on n'a pas besoin d'affaiblir les parties endommagées des pierres, afin de les géométriser.

L'avantage le plus important des mastics et des mortiers donne la possibilité de régler leurs propriétés physiques et leurs qualités mécaniques qui s'adaptent aux propriétés et qualités des pierres du monument traité. Comme par le passé cette possibilité a été très peu utilisée. En général on utilise les mortiers et les mastics de composition fortuite; leurs propriétés sont différentes des pierres des monuments traités. Le plus souvent les restaurateurs s'efforcent d'obtenir le mortier ou le mastic trop résistant et trop compact. Tels mortiers et tels mastics diffèrent des coefficients de la dilatabilité thermique et sous l'influence des facteurs extérieurs se produit l'altération de la pierre. Les mortiers se détachent de l'empierrement altéré. C'est pourquoi les mortiers et les mastics impropres peuvent accélérer l'altération des pierres.

Les mortiers et les mastics employés devraient avoir les propriétés suivantes:

1. Avoir la résistance pareille, le coefficient de la dilatabilité thermique et la porosité analogue à la pierre traitée.
2. Devraient être résistants contre l'action de l'humidité, contre les changements de la température et contre les polluants de l'atmosphère, de même qu'ils devraient durcir sans contraction et avoir une adhésion parfaite à la pierre naturelle.
3. Ils ne devraient pas contenir de sels solubles dans l'eau ou d'autres substances capables d'agir nuisiblement à la pierre.

I.

Depuis une vingtaine d'années le Laboratoire Chimique du Musée National à Poznan en collaboration avec les instituts universitaires et techniques effectue de nombreux études et recherches consacrés à des observations et à des vérifications sur l'emploi des différentes substances et méthodes dans la conservation des monuments et des objets en pierre. On peut discerner deux lignes d'évolution de ces recherches. La première contient les observations, les examens et les expériences sur les effets des consolidations effectuées dans le passé, la deuxième renferme les recherches visant à vérifier les valeurs effectives des consolidations exécutées avec les résines synthétiques.

Dernièrement nous avons effectué en collaboration avec l'Institut de Conservation des Biens Culturels de l'Université N. Kopernik à Torun quelques recherches complexes et communes afin d'approfondir les éléments d'appréciation d'ordre scientifique et afin d'élaborer les critères objectifs d'évaluation des méthodes de traitement des pierres altérées.

Les méthodes dont nous disposons maintenant pour traiter les monuments en pierre sont, soit le fruit des expériences remontant au passé bien loin de nous, soit le fruit des diverses inventions contemporaines. Afin de rendre possible le progrès accéléré de la technique conservatrice il semble nécessaire de tirer profit des expériences anciennes ainsi que des inventions contemporaines.

Nous avons présenté au colloque de l'ICOMOS et du Centro delle Sculture all'Aperto à Bologne, en Octobre passé, les résultats de la recherche sur l'affermissement de la pierre avec les solutions des résines thermoplastiques. Le présent rapport et le second rapport commun contiennent les résultats des recherches sur les mastics utilisés pour combler les dégâts et les pertes du matériau des monuments altérés.

1. Le monument représentatif que nous avons examiné dans le laboratoire du Musée National à Poznan, était la Chapelle Royale à Gdansk. La décoration sculptée de la façade a été exécutée en pierre, grès glaucolitique polonais de la carrière de Brenna, par un éminent sculpteur du XVIIème siècle, Schlueter.

Les décorations sculptées d'une qualité remarquable ont été réparées plusieurs fois à partir de la fin du XVIIIème siècle, jusqu'à la 3ème décade du XXème siècle. On a distingué 11 diverses sortes de mastics utilisés pendant les conservations successives des sculptures dans le passé, exécutées pour le comblement les dégâts des sculptures. L'état de la façade de la Chapelle Royale à Gdansk avant et pendant la conservation contemporaine est présenté par les transparents. Les autres montrent les détails et les lieux où nous avons pris les échantillons pour les recherches.

2. La composition des mastics examinés était bien diverse. Le tableau n°1 présente des proportions de liants et de charge. Dans la charge on a trouvé partout les grains fins du sable de quartzite. En outre on a trouvé dans l'échantillon n.10 du charbon et de la brique broyés des fibres végétales et du crin dans les échantillons N.3a et 3b.

Tableau n°1

Les proportions de liants et de charge dans les mastics:

Echantillon n°	Le liant parties vol.	La charge parties vol.
1.	3	2
2.	1	1
3a.	3	2
3b.	3	2
4.	1	1
5.	1	1
6.	1	1
7./grès glaukol./	1	9
8.	2	3
9.	4	1
10.	1	1
11.	1	3
12.	1	2

Tableau n°2

Les proportions de liants et de charge dans les mastics examinés:

Echantillon	partie de volume					
	chaux	plâtre	ciment	caséine	KNaSiO_3	KA1/SiF_6
1.	1	2	3	-	-	m-
2.	3	1	1	-	-	-
3a.	2	1	-	0,1	-	-
3b.	2	2	-	0,1	-	-
4.	2	1	-	0,05	-	-
5.	1	-	2	-	-	-
6.	1	1	1	-	0,03	0,02
7.	-	-	-	sup.	-	sup.
8.	3	1	-	0,05	-	-
9.	1	2	-	-	-	0,02
10.	-	1	1	-	-	-
11.	1	-	-	0,1	-	-
12.	1	-	0,03	0,01	-	-

sup. = présence sur la surface.

Le tableau n°2 présente des proportions des composants des liants. On peut remarquer la présence de caséine dans les échantillons 3a, 3b, 4, 8, 11 et 12. On a trouvé aussi des silicates et des fluosilicates dans les échantillons n°6 et 9, qui sont introduits dans le passé par le traitement d'affermissement de la pierre, exécuté d'après les méthodes de Fuchs et de Kessler. On a utilisé le verre aqueux et les fluosilicates.

3. Les qualités techniques et les propriétés physiques sont présentées par le tableau n°3. L'échantillon n°7 présente les qualités de la pierre. Comme chacun le voit, seulement les mastics représentés par les échantillons 2 et 6 sont plus compacts que la pierre, et de cette raison ils exercent une influence nocive sur la pierre comblée. Les mastics représentés par les échantillons n°1, 6 et 8 peuvent être reconnus nocifs à cause du coefficient d'imbibition de plus que 0,9 par rapport à la porosité. Les mastics représentés par les échantillons n°6 et 9 peuvent être reconnus nocifs à cause de la présence de sels solubles dans l'eau.

Tableau n°3

Qualités techniques des mastics:

Echantillon	Poids vol.	Poids spec.	Porosité %	Imbibition %	Résistance pression kg/cm ²
1.	2,02	2,66	24,1	24,7	50
2.	2,40	2,60	7,7	6,1	30
3a.	1,26	2,54	50,4	26,1	10
3b.	1,80	2,36	23,8	14,9	12
4.	1,66	2,36	29,7	25,7	7
5.	1,66	2,46	32,5	21,5	35
6.	2,42	2,60	6,9	7,3	35
7.	2,24	2,56	12,5	11,4	250
8.	2,12	2,58	17,8	16,2	15
9.	1,28	2,30	44,0	14,9	5
10.	2,14	2,66	19,6	16,2	35
11.	1,26	2,30	45,2	35,7	8
12.	1,71	2,56	23,8	14,9	12

Tableau n°4

Hygroscopicité des mastics:

Echantillon	teneur de l'eau - temp. 20°C, rH = en%		
	40%	60%	99%
1.	0,20	1,50	1,86
2.	0,08	1,65	3,79
3a.	0,90	1,27	1,68
3b.	0,08	0,92	3,12
4.	0,85	1,17	1,85
5.	0,75	1,51	4,43
6.	0,95	1,92	3,53
7.	0,04	0,48	0,61
8.	0,38	0,79	3,02
9.	0,32	0,61	2,78
10.	0,72	1,94	2,59
11.	1,47	3,25	3,45
12.	0,43	0,64	0,87

Le tableau n°4 présente l'hygroscopicité des mastics. Les déterminations ont été exécutées par gravimétrie. On a réglé par les sels hydratés l'humidité relative de l'air ambiant.

Du point de vue de l'équilibre entre l'humidité de la pierre et le mastic, les échantillons n°1,2,3b,5,6,8,9 et 10 représentent les mastics subissant l'altération accélérée.

Tableau n°5

Parties volatiles, solubles, l'humidité et réaction pH:

Echantillon	%				
	Humidité	Pertes de grillage	Parties solub. dans l'eau	Parties insol. dans HCl	
1.	1,5	19,3	1,8	53,0	6,1
2.	1,6	27,3	1,2	63,5	7,2
3a.	1,3	16,3	0,7	64,9	7,0
3b.	0,9	17,5	0,8	55,2	7,1
4.	1,2	12,5	0,9	77,2	7,6
5.	1,5	14,3	0,9	16,4	7,4
6.	1,9	11,3	1,1	74,9	7,0
7.	0,5	3,1	0,3	89,9	7,0
8.	0,8	12,1	0,9	64,4	7,2
9.	0,6	34,3	0,4	62,0	7,3
10.	1,9	11,3	0,8	79,8	7,8
11.	3,3	10,8	1,4	56,7	7,1
12.	0,6	13,3	1,6	67,8	7,0

Tableau n°6

Composition chimique:

Echantillon	Parties insol. dans HCl%	%					
		Al ₂ O ₃	Fe ₂ O ₃	CaO+MgO	CO ₂	SO ₃	Cl
1.	53,0	5,6	0,7	26,6	16,4	0,7	0,3
2.	63,5	0,4	0,4	18,7	13,2	0,2	0,1
3a.	64,9	0,1	tr.	21,9	7,3	10,1	tr.
3b.	55,2	tr.	tr.	20,5	3,4	9,3	tr.
4.	77,2	0,1	tr.	19,3	4,2	10,3	tr.
5.	16,4	7,4	0,7	21,7	4,9	9,5	tr.
6.	75,0	4,7	0,5	12,2	3,2	1,2	tr.
7.	89,9	0,8	tr.	4,1	1,3	tr.	tr.
8.	64,4	0,4	0,3	14,9	7,1	tr.	tr.
9.	62,0	1,8	0,4	13,7	3,1	4,9	tr.
10.	79,8	5,2	0,6	8,4	3,8	6,3	tr.
11.	56,7	0,2	0,2	11,3	2,7	0,1	tr.
12.	67,8	0,1	0,1	15,6	10,3	tr.	tr.

4. Les tableaux n° 5 et 6 présentent les caractéristiques et les compositions chimiques des mastics examinés. Le tableau n° 5 montre que la solidité des mastics n°1,2,4,6,10,11 et 12 à cause de leur teneur en humidité, parts solubles dans l'eau et de leur réaction pH est insuffisante.

Le tableau n°6 montre la composition chimique élémentaire des mastics examinés. Ils sont très divers.

Les qualités techniques, les propriétés physiques, les caractéristiques et la composition chimique des mastics n'étaient pas appropriées en rapport à la pierre glaucolitique des décorations sculptées. De cette raison ils ont mal agi sur la pierre des décorations en provoquant l'altération accélérée. Même les mastics ont subi la détérioration.

II.

Afin d'obtenir que les mortiers et les mastics agissent bien sur la pierre et qu'ils soient résistants et durables, on effectue depuis près de vingt ans dans l'Institut de Conservation des Biens Culturels à l'Université Kopernik à Torun, les recherches technologiques des mortiers et des mastics basées sur les liants inorganiques et organiques. On a obtenu des résultats intéressants en employant les résines époxydes en mélange avec la charge minérale /grès, calcaire, sable/.

1. On a utilisé la résine époxyde polonaise Epidian 5, qui est semblable aux Epon 828 américaine et Araldit F suisse.

Comme durcisseur on a utilisé du triéthylène-tétramine. On a examiné d'abord la capacité de durcir de la résine dans la température normale, la capacité de durcir en mélange avec la charge et les propriétés des mastics et des mortiers préparés sur la base de cette résine.

En examinant la capacité de durcir de la résine époxyde dans la température normale, on a constaté que le temps et la teneur de polyamine influencent décisivement le durcissement de la résine. Conformément à leur agrandissement la résistance mécanique augmente. Cela est montré par le tableau n°7.

Tableau n°7

Influence du temps de durcissement dans la température normale et de concentration du durcisseur sur la résistance mécanique de la résine époxyde:

La résine - Epidian 5

La température moyenne ambiante - 22°C.

Concentration du durcisseur en %	temps de durcissement en jours			
	2	12	20	126
	résistance flexion en Kg/cm ²			
10% proportion sté- chiométrique	479	548	570	560
15	440	608	857	1100
20	760	893	1146	1517

Comme on voit le durcissement de la résine dans la température normale se passe lentement. La teneur de polyamine influence considérablement la résistance.

2. La résistance des échantillons augmente même après 20 jours arrivant à une résistance pareille aux échantillons durcis dans la température élevée, comme on voit sur le tableau n°8.

Tableau n°8

Influence de concentration de polyamine et de température élevée sur les propriétés de la résine époxyde Epidian 5:

Temps de durcissement - 3 heures

Température - 80°C.

Concentration du durcisseur en %	Résistance flexion Kg/cm ²	Augmentation de résistance %
10	1056	-
15	1226	16
20	1347	28

3. On ne remarque pas une influence du temps et de la teneur de polyamine sur la résistance de la résine époxyde dans le cas de mélange de la résine avec une quantité considérable de charge minérale. La température se révèle comme un facteur unique influençant le durcissement. Cela est expliqué par le tableau n°9.

Tableau n°9

Influence de la concentration de polyamine et de la température de durcissement sur les propriétés des mastics:

Proportion résine - sable = 1 : 10

Granulation du sable = 0,125/0,250 mm.

Concentration du durcisseur en %	Température du durcissement		
	16-20°C	160°C	
	30 jours	1 heure	
Kg/cm ²	Résistance flexion		Résistance pression
10	-	222	566
15	-	206	-
20	104	257	519

On voit cela encore plus clairement dans le cas qu'on emploie une quantité plus grande de charge en rapport à la quantité de résine. Le tableau n°10 contient les données.

Tableau n°10

Influence de la température sur la résistance mécanique des mastics époxydes avec sable:

Proportion résine-sable = 1 : 50

Granulation du sable = 0,125/0,250 mm.

Température du durcissement en °C	temps du durcissement	résistance flexion Kg/cm ²	résistance pression Kg/cm ²
normale	50 jours	7	17
80	3 heures	41	65
100	"	48	83
130	"	58	144
160	"	64	144

Comme on voit sur le tableau 10 les mastics avec une teneur considérable de charge se sont durcis dans la température normale si faiblement du point de vue de la résistance mécanique, qu'ils ne peuvent pas être utilisés.

4. Les expériences effectuées ont permis d'expliquer la cause de ce phénomène, et cela a rendu possible de trouver la manière d'agir qui permette un durcissement complet dans la température normale avec une quantité quelconque de charge. On a constaté que le facteur principal arrêtant le processus de durcissement des résines époxydes, dans la température normale en utilisant les polyamines aliphatiques, est le dioxyde carbonique, dont l'activité augmente par rapport à l'humidité de l'air.

L'acide carbonique qui se produit réagit contre l'amine et forme des sels à cause desquels les mobiles atomes d'hydrogène des amines sont bloqués. Le processus se révèle en particulier dans le cas d'enduits époxydes minces. Quant à la possibilité de diffusion du dioxyde carbonique et d'humidité dans l'enduit, il y a la possibilité d'arrêter complètement la réaction de durcissement de la résine. On produit ces conditions défavorables en mélangeant la résine époxyde avec une grande quantité de charge.

Les mastics obtenus ont dans ce cas une grande porosité qui rend possible l'influence du dioxyde carbonique dans toute la masse du mastic, et les enduits qui se produisent sur les grains de la charge sont très minces: s'il y a plus de charge, plus grande est la superficie de leurs grains. Par exemple 1 Kg. de charge de fraction 0,074 - 0,149 mm. a une superficie de 25 m². En cas de mélange dans la proportion d'1 part de résine : 50 parts de charge l'épaisseur de la pellicule qui se produit sur les grains sera de 0,7 microns. L'enduit si mince permet la diffusion libre des gaz et des vapeurs, de même qu'une déactivation de polyamine. Afin de prévenir cela, on ajoute au mélange des résines, de la charge et de polyamines, les solvants d'une moyenne volatilité, dans lesquels la résine n'est pas soluble. Les solvants comblent les pores dans les mastics et les protègent contre l'influence de l'ambiance; en outre ils rendent possible le durcissement de la résine. Dans ce but, il faut utiliser le meilleur white spirit / essence de vernissage / ou l'essence de térébenthine.

5. On peut utiliser aussi les solutions des résines. Par exemple en mélangeant le sable avec 20% de résine époxyde dans la proportion telle que une part de résine soit mélangée avec 30 parts de sable, dont, après durcissement dans la température normale, on a produit les échantillons dont la résistance était pareille à celle des échantillons durcis par échauffement. Dans ce cas, la solution a rempli les pores en protégeant la résine contre l'activité des gaz atmosphériques. Les résultats sont présentés sur le tableau n°11.

Tableau n°11

Influence des solvants / tluol + méthanol 1 : 2 / sur le durcissement de la résine époxyde dans les mastics:

Proportion résine-sable = 1 : 30

Température du durcissement - normale

Expériment	Temps du durcissement en jours.Temp.norm.	Résistance pression ₂ Kg/cm ²	
sans solvants	3 h. en 80°C et 1 h. en 160°C	186	
avec solvants	25 40 70	158 149 175	

6. Les qualités mécaniques des mastics sont influencées par les autres facteurs, les plus importants desquels sont l'espèce de la charge, sa granulation et la proportion à la résine.

Afin de déterminer l'influence de la charge on a mélangé la résine avec la même quantité de différentes charges. Les résultats sont présentés dans le tableau n°12.

Tableau n°12

Influence de l'espèce de charge sur les qualités mécaniques des mastics époxydes:

Espèce de charge	Poids vol.	Résistance flex.	Pression	
marbre	1,587	250	564	
sable	1,600	233	538	
grès broyé	1,372	145	405	
brique broyée	1,145	130	176	

Proportion résine-charge = 1 : 10

Granulation de la charge = 0,125/0,500 mm.

Comme on voit, les qualités mécaniques sont déterminées par le poids volumétrique de la charge. En outre ils sont influencés par la morphologie des grains de la charge. Si les grains sont ronds et lisses ils ont une moindre superficie et la résine pro-

duit des pellicules plus épaisses et plus grandes menisques parmi les grains, en résultant la plus grande force de collage.

L'influence de la granulation de la charge, en particulier sur les propriétés des mortiers et des bétons est connue partout. Tout le monde sait que la charge la plus compacte a besoin d'une quantité minime de liant afin d'enduire les grains, et de même, grâce à une quantité très grande de menisques parmi les grains, on obtient une très grande résistance mécanique. Cette règle est valable aussi dans le cas de la résine époxyde, comme le liant. On peut voir ceci sur le tableau n°13.

Tableau n°13
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Influence de la granulation de la charge sur les qualités mécaniques des mastics époxydes:
Proportion résine-sable = 1 : 50.

Granulation de la charge en mm.	Poids vol. de mastic en g/cm ³	Résistance pression en Kg/cm ²
100% 0,125-0,25	1,559	147
80% 0,25-0,5 20% 0,06-0,12	1,840	217
60% 1,0-1,6 40% 0,12-0,25	1,933	222

Comme on aperçoit sur le tableau, les résultats les plus favorables ont été obtenus en utilisant les mélanges des charges les plus compactes ayant le poids volumétrique le plus grand. Le rôle de la quantité de la charge en rapport à la résine est aussi clair. En augmentant sa quantité nous causons la création des menisques plus petits parmi les grains, et de même on diminue la force de collage. Cette relation entre la proportion de la charge et la force de collage est montrée sur le tableau n°14.

Tableau n°14
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Influence de la proportion de la charge sur les qualités mécaniques des mastics époxydes:

Granulation du sable = 0,25/0,5 mm.

Granulation du grès broyé = 0,0/1,0 mm.

Espèce de charge	Proportion résine-charge	Poids vol. du mastic g/cm ³	Résistance pression Kg/cm ²
Grès broyé	1 : 5	1,757	658
	1 : 7,5	1,678	478
	1 : 10	1,620	405
	1 : 12,5	1,540	201
Sable	1 : 10	1,766	538
	1 : 30	1,626	186
	1 : 50	1,590	138

Dans ce tableau on peut conclure que la diminution de résistance et l'augmentation de la proportion de la charge sont liées avec la diminution du poids volumétrique. Il s'ensuit que les pellicules résineuses internes couvrant les grains sont minces. Il en résulte l'augmentation de la friction et les poids volumétriques s'approchent au poids volumétrique de la charge sèche. Au contraire, les pellicules plus épaisses facilitent le glissement parmi les grains et rendent possible la condensation de la structure.

En résumant, il faut constater qu'en choisissant la sorte de charge appropriée, sa granulation et sa proportion par rapport à la résine époxyde on peut régler dans des limites assez larges les qualités mécaniques des mastics et leurs poids volumétriques de même que leurs porosités. Il y a donc la possibilité de préparer les mastics appropriés aux pierres dans les monuments.

Les autres avantages sont l'adhésion parfaite aux pierres et la possibilité de durcir sans dilatation dans les couches d'épaisseur à volonté, l'absence de substances nuisibles pour la pierre et une résistance assez grande contre l'action de l'humidité, du gel et des gaz atmosphériques, de même que l'imbibition limitée malgré une grande porosité / p.e. dans le rapport résine-sable 1 : 30 résulte environ 3%: résultat par les propriétés hydrofuges de la résine. L'eau peut pénétrer seulement jusqu'à une profondeur limitée / quelques millimètres / de la surface. Les examens compara-

tifs ont révélé que l'imbibition avec l'eau est environ 70% moindre que l'imbibition avec l'essence.

Il faut souligner qu'en choisissant une sorte appropriée de charge, de sa granulation et proportion, non seulement peut-on obtenir des mastics caractérisés par les propriétés physico-mécaniques semblables à celles des pierres traitées, mais aussi leur apparence est pareille à l'original, et on peut intégrer le lieu complété avec l'objet.

Il faut ajouter en outre, qu'il est possible d'imiter les roches ignées, les grès et les calcaires.

Wiesław Domasłowski

Institut de Conservation des
Biens Culturels
de l'Université Kopernik
à Torun - Pologne

Janusz Lehmann
Musée National
à Poznan - Pologne

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COMITE DE CONSERVATION// COMITE POUR LA CONSERVATION

Madrid, 2-8 octobre 1972

Activité chimique des sels solubles sur les matériaux poreux de construction.

José María Cabrera Garrido

8981 26

Activité chimique des sels solubles sur les constructions de construction. (3)

Lorsqu'on étudie les altérations des calcaires collés à la Cathédrale de Cadix, les ruptures se justifient par la cristallisation de sels à l'intérieur de la matrice exocristalline.

Infantez(1) identifie les sels comme CaSO_4 principalement, qu'il trouve dans la masse des pierres analysées, sans doute comme origine de ceux-ci la mer proche du temple.

Mais, à l'occasion du récent Programme d'études sur l'altération de la Cathédrale de Cadix(2), on a pu établir avec assez de précision que les abondantes efflorescences salines qui existent sur les murs, cause évidente des dégâts les plus importants, ont un rapport entre leur nature et les divers niveaux sur les murs, c'est-à-dire:

- Dans le sous-sols..... $\text{SO}_4\text{Na}_2 \cdot n\text{H}_2\text{O}$ (3)

Sur les parements intérieurs } - jusqu'à 2m. de haut..... $\text{SO}_4\text{Na}_2 \cdot n\text{H}_2\text{O}$ +
térieurs des murs. } $\text{CO}_3\text{Na}_2 \cdot n\text{H}_2\text{O}$.
- en zones élevées..... $\text{CO}_3\text{Na}_2 \cdot n\text{H}_2\text{O}$.

- Sur les parements extérieurs..... CaSO_4 .

- Sur quelques échantillons d'efflorescences à base de CO_3Na_2 de formation récente, nous constatons la présence de NaOH. Nous voyons que les sels tombent sur paviment du temple, l'analyse montre une mélange de Carbonate-Bicarbonate de Na.

- (1) Infantez Herrero, J. "Erosión de la Catedral de Cadix" au Symposium sur l'altération des matériaux pierreux dans les monuments. ICCC/CSIC, Madrid (1967), pp. 127-134.
- (2) Cabrera, J. M. y Cabrera, P. "Programa de estudios para la Conservación de la Catedral de Cadix", Rapport 24/11/49-5/1970, ICCC.
- (3) Le degré d'hydratation varie amplement mais il est généralement proche de 10.
- (4) Extrait du ch. 1.5 du Programme-1971 sous le Patronage de la "Fundación Juan March".

[illegible]

caires pour donner
des processus qui ne sont point absolument clairs.

(4) Référence prise de Vign., Av. Madrid (1961)p. 100-102.

(5) Référence applicable au NO₂, et elle est citée dans Quinac, Edt. Aguilon, 7e éd., Madrid (1961), p. 100-102.

(6) "Cel de Veracruz, de Xoré, de Zacatecas, de Toluca, de Cuernavaca, de la carne de Chichilauhtlan, en Descripci6n de la Nueva España, año 1770, en los Pedernales." en Descripci6n por el ilustre Sr. Cabildo año de Cádiz, presenté par le

Le principe est bien évident : les deux actions se
centrent la décomposition du chlorure d'hydrogène
de sodium selon l'idée avancée par Berthollet et démontre
boute Soudure des ions sodium (7) met, et autres effets,
que tous les chercheurs ont centré leur intérêt sur les effets
mécaniques produits par la cristallisation des sels, spécialement
l'ancienne théorie qu'il est difficile de maintenir. Stenbolov
Van Asperen de Boer nous indiquent, à peu près, (8) que les sels
sont considérés comme les plus dangereux et leur action se

(7) On lit, fréquemment (par ex. Espasa-Calpe, Dict., Vol 53, pg. 66-67 et Vol. 5, pg. 410) que "l'action du sel, comme agent chimique puissant, doit être par conséquent un facteur de métamorphisme des éléments des roches."; ceci vient habituellement, par extension d'une autre idée plus simple: "...là où le ClNa provoque des actions chimiques de plus grande importance c'est en agissant sur certaines des roches plus répandues sur la croûte terrestre et qu'il a le pouvoir de décomposer; ainsi, sous l'influence de l'air et de l'eau, il se combine au CO_2Ca produisant Cl_2Ca et CO_2Na_2 ...".

duisant Cl_2Ca et CO_3Na_2 ... Cette idée, amplement diffusée dans la bibliographie, provient des observations réalisées par Berthollet ("Observations sur le Natron", Paris, 1801) lorsqu'il accompagna Napoléon dans son expédition en Egypte, en 1799. Nous retrouvons cette idée recueillie dans des livres que l'on emploie comme texte dans les Universités et, par exemple, Moore, W. J. "Physical Chemistry", Prentice-Hall, New York, 1950, p. 62-63, nous dit que "...il se-
 vait que la réaction $\text{CO}_3\text{Na}_2 + \text{Cl}_2\text{Ca} \rightarrow \text{CO}_3\text{Ca} + 2\text{ClNa}$, comme on la réalise dans les laboratoires, était totale en précipitant tout le CO_3Ca , mais Berthollet dut admettre cependant que, quoiqu'il existait un grand excès de ClNa , comme cela se passait dans les salines en évaporation, la réaction pouvait être inversée en transformant la calcite en carbonate de sodium...".

(3) Stambolov, I. et Van Asperen de Boer, J. R. J. "The deterioration and conservation of porous buildings materials" ICOM-Committee for Conservation, Brussels (1967) et Amsterdam (1969) p. 4-9 et 2-5 respectively.

De ces faits, pour les Chlorures, les Sulfates, se déduisent les conclusions suivantes: étant hygroscopiques, ils se dissolvent rapidement quand l'humidité condense et, une fois en dissolution, agissent activement sur le trois aspect fondamentaux, 1) ils sont extraordinairement mobiles, agissant et rompant de nombreuses structures cristallines, 2) ils facilitent la suspension dans l'eau de grande agglomération de solides, 3) ils augmentent le manque d'esthiométrie dans les chlorures; les Nitrates et les sels d'acides organiques agissent de façon similaire aux Chlorures.

Enfin, (9) suit la même ligne, indiquant comme principal agent d'altération l'activité mécanique des sels; il fait aussi une révision bibliographique des travaux publiés dans "Chimie der Erde" entre 1926 et 1938, et fait les remarques suivantes que nous soulignons.

(9) Enigüez Herrero, J. "Alteración de calizas y areniscas como materiales de construcción", Publ. du Minist. d'Educación Nacional le D.C.B.A., Madrid (1961) pg. 24-43, d'après Storz, "Chimie der Erde", vol. XI, p. 485.

Storz, en étudiant les falaises dalmates (calcaire de Flysch), attribue l'altération à la présence de Chlorures et Plâtre; travaillant avec du Carbonate de Calcium pur pulvérisé et des solutions préparées avec des Chlorures de Sodium, Potassium, Magnésium, Sulfate de Magnésium et, l'une d'elles, du Plâtre, il obtient que les solutions sans Plâtre et l'eau distillée ont un pH acide (5,2 à 6,6) même après avoir ajouté du CO_2 et que la solution avec Plâtre atteint un pH de 8,8 après addition de CO_2 , quelle que soit la concentration des autres sels; Storz conclut que la solubilité du Carbonate de Calcium est donc beaucoup plus grande pour l'eau de mer que pour la distillée, et indique que l'on a dû produire une réaction (comme celle de Berthollet), et que le Carbonate de Sodium formé, malgré le fait de produire un pH égal à celui d'une solution $\frac{1}{10^5}$ M du même produit, est assez significatif. Ceci est loin d'être logique étant donné l'action du Calcium comme ion commun au Sulfate et Carbonate, et ne correspond pas avec les expériences que nous avons effectuées.

nous avec intérêt:

a.) sur les observations de Stora concernant l'action chimique de dissolutions salines sur le CO_3Ca et la formation de CO_3Na_2 , il note que tout cela permettrait d'expliquer certains types d'altérations, mais ne peut être le facteur le plus important, car la présence de Chlorures n'est pas très fréquente hors des zones côtières.

b) il commente aussi la réaction $\text{CO}_3\text{Ca}(\text{sol}) + \text{SO}_4\text{Na}_2(\text{liq}) = \text{SO}_4\text{Ca}(\text{sol}) + \text{CO}_3\text{Na}_2(\text{liq})$, notant qu'elle ne peut avoir lieu qu'en petite quantité en raison du rapport d'équilibre $\text{CO}_3 = \text{SO}_4 = 1,56 \times 10^{-4}$.

c) il insiste spécialement sur les divers sels doubles qui peuvent se former à partir des ions Sulfate, Chlorure, Sodium, Potassium, Calcium et Magnésium.

Dans notre travail, les premiers pas pour l'étude du problème nous conduisent à l'examen direct des observations faites par Berthollet(10):

".. Quelques substances salines, et particulièrement le Carbonate de soude, ont la propriété de se séparer des substances avec lesquelles elles se trouvent en combinaison, dans un certain degré d'humidité; Schéele (Mém. de Chim. t. II) est le premier qui ait aperçu que cette propriété pouvait produire des changements dans les combinaisons..."

" 224. Si le muriate de soude se trouve en concurrence avec la chaux dans un degré convenable d'humidité, l'action de la soude sur l'acide muriatique est affaiblie par là; elle partage celle de la chaux sur l'acide carbonique qui se trouve dans l'air atmosphérique; mais diminuée par la saturation,

(10) Berthollet, C.L. "Essai de Statique Chimique" 2 vols. Paris (1803). 1er partie "Des limites de la combinaison" Chap. III "De l'efflorescence", Vol. I, pg. 403-409.

elle serait venue en efflorescence, comme il résulte de l'observation du Carbonate de chaux, s'il ne se trouvait une circonstance déviée par l'efflorescence: la décomposition de l'acide de soude continue donc jusqu'à ce qu'il se soit formé assez de muriate de chaux, parce que l'acide muriatique devant se partager entre les deux bases en raison de leur action, il arrive un terme où leurs forces se balancent. La petite quantité d'acide carbonique qui se combine d'abord dans la masse totale, ne produit pas une force de cohésion qui puisse l'emporter sur les forces opposées (11); seulement elle suffit pour déterminer successivement l'efflorescence, mais si l'on met en dissolution tout-à-coup la quantité de carbonate qui s'est séparée, la force de cohésion a alors assez d'intensité pour précipiter le carbonate de chaux, et l'on obtient des combinaisons opposées par cette seule condition des quantités.."

".. L'efflorescence produit de même une séparation de carbonate de soude, lorsque celui-ci se trouve en contact avec le carbonate de chaux dans un degré d'humidité convenable; alors il se fait une très petite dissolution du carbonate de chaux, au moyen de l'action qu'exerce sur lui le muriate de soude; mais la combinaison de l'acide carbonique avec la soude, et sa séparation simultanée sont décidées par la disposition à l'efflorescence, et la phénomène se continue. Les circonstances qui peuvent favoriser l'efflorescence sont

(11) note (77).:

"...selon les observations de Guyton (l'idée de Schéele part. IV note de la page 18), la dissolution de SO_4K_2 , du muriate de potasse, etc., versée dans l'eau de Chaux rendue laiteuse par l'acide chargé du CO_2 ; fait disparaître sur-le-champ le pp.; également il n'y a pas de pp quand l'on verse ^{sur} le mélange de l'eau de chaux et de dissolutions de ces sels neutres, de l'eau avec du CO_2 ..."

un mélange convernable de muriate de soude et de carbonate de chaux, et une humidité soutenue à une température élevée; le voisinage d'un corps poreux favorise encore la décomposition du muriate de soude, en facilitant l'efflorescence et la séparation du carbonate de soude; mais quoiqu'il y ait peu de différence entre les conditions de cette décomposition et celle qu'on obtient par la chaux, il paraît que la première exige un intervalle de temps beaucoup plus grand, et peut-être quelques circonstances plus favorables, telles qu'une température plus élevée; d'où vient, probablement, que Schéele n'a pas obtenu cette décomposition en se servant du carbonate de chaux."

" 225. C'est par ces circonstances, que j'ai observées sur les bords du lac Natron, que j'ai cru pouvoir expliquer la formation continuelle d'une immense quantité de carbonate de soude (Mém. sur l'Egypte), et il est probable que c'est à des circonstances semblables ou peu différentes, qu'est due la production du carbonate de soude qu'on observe dans d'autres déserts, ainsi que sur la surface de quelques voûtes et de quelques murs..".

" 226. Quoique l'efflorescence soit une propriété plus énergique dans le carbonate de dans les autres sels, plusieurs de ceux-ci n'en sont pas dépourvus; c'est elle qui me paraît être cause que dans les plâtras imprégnés de salpêtre, le nitrate de potasse se sépare des sels à base terreuse, et se trouve principalement dans les parties les plus élevées, pendant que celles qui sont voisines du sol contiennent sur-tout du sel à base de chaux. C'est à la même propriété que me paraît due la formation du sulfate d'alumine qui a lieu à la surface de granites, des porphyres qu'on tient pendant long-temps humectés d'acide sulfurique, comme l'a fait Bayen (Journ. de Phys. 1779), lequel s'en est servi avantageusement pour l'analyse de ces pierres."

".. Quoique l'efflorescence ne produise qu'un petit

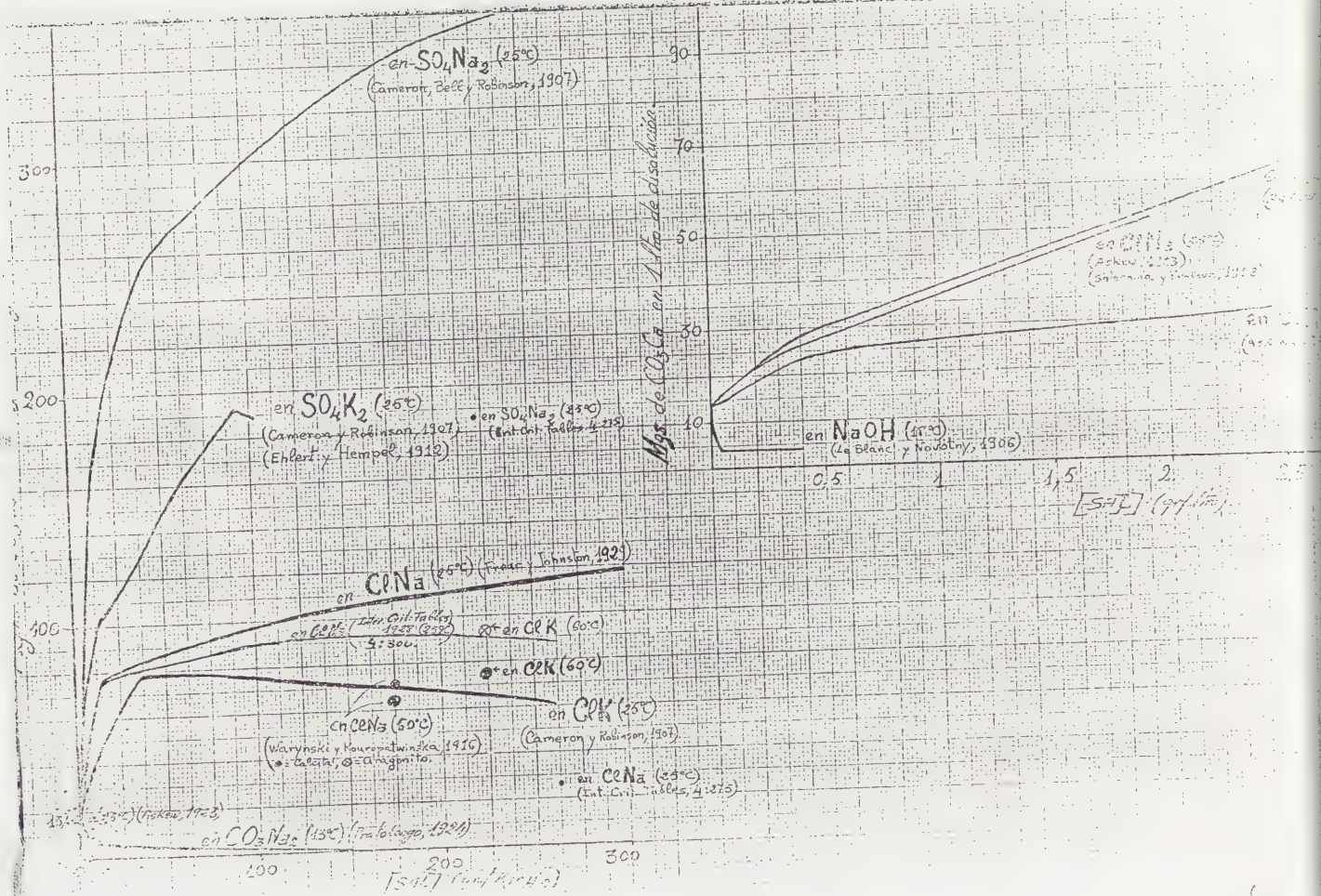
nombre d'effets, elle ne doit cependant pas être négligée, puisqu'elle sert à expliquer la production de quelques combinaisons qui sont opposées à celles qui se forment dans les circonstances ordinaires, et qu'elle peut devenir d'une application utile dans les arts."

Pour l'étude des équilibres dans les diverses réactions à envisager, nous avons recueilli les valeurs des solubilités connues(12). Comme nous remarquons que les données apportées par différents auteurs sont souvent en désaccord, nous résumons de façon graphique cette information, indiquant le nom de l'auteur et la date de la publication.

(12) Proviennent de :

- Linke, W.F. "Solubilities: inorganic and metal organic compounds", D. Van Nostrand Co, Inc. New York (1958) Vol. I, pg. 536-556.
- Seidell, A. "Solubilities of Inorganic and metal organic compounds", D. Van Nostrand Co. Princeton (1940), 3^e éd., Vol. I, pg. 264-276.
- Stephen, H. and Stephen, T. "Solubilities of Inorganic and Organic Compounds", Pergamon Press (1963), Vol. I, Partie 1, tableaux 632 et 639-643.
- "International Critical Tables of Numerical Data", McGraw-Hill Book Co, New York (1926).

Elles représentent un recueil massif de solubilités avec références aux sources originales. Les données de solubilité qui s'y trouvent, ne sont pas interprétées en termes de constantes d'équilibre.



Prosser et Johnston (1922) considèrent que les résultats obtenus par Cameron et collaborateurs n'ont qu'une signification qualitative, car les conditions expérimentales sont insuffisamment contrôlées.

Au point de vue qualitatif, d'autres auteurs apportent des données significatives:

- Stieglitz (J.A.C.S. 30(1908). 9460) indique que la loi du produit de solubilité répond de façon satisfaisante pour les solutions saturées d'électrolytes peu solubles qui contiennent des sels étrangers, dans l'hypothèse où la concentration totale du sel ne dépasse pas 0,3 M., mais ne peut s'appliquer rigoureusement à des sels peu solubles en présence d'une grande concentration de sels étrangers.

- Dubrisay et François (1931), dans un essai de rechercher si les sels de Potassium agissent sur le CO_3Ca selon la réaction réversible $\text{CaCO}_3 + 2\text{KCl} = \text{K}_2\text{CO}_3 + \text{CaCl}_2$, montrent qu'une solution aqueuse de Chlorure Potassique en concentrations croissantes, saturée avec du Carbonate de Calcium en l'absence de CO_2 , exige des quantités croissantes de H_2SO_4 N/3 pour neutraliser son alcalinité.

- Leik (1932), détermine que la solubilité du CO_3Ca à 100°C est de 0,0375 gr/ltr. mais que cette valeur varie avec l'excès de CO_3Ca présent dans le mélange pendant la période de chauffage et aussi, que le contenu de CO_3Ca dissous augmente avec la présence de ClNa et SO_4Na_2 et diminue avec NaOH et CO_3Na_2 .

- Bouéline et Bykof (1935) montrent qu'il existe beaucoup plus de Bicarbonate dans le système $\text{CaCO}_3 + \text{K}_2\text{SO}_4 + \text{H}_2\text{O}$ que dans le système $\text{CaCO}_3 + \text{CO}_2 + \text{H}_2\text{O}$, en raison de la réaction $\text{Ca}(\text{HCO}_3)_2 + \text{K}_2\text{SO}_4 = 2\text{KHCO}_3 + \text{CaSO}_4$.

Solubilité du carbonate de calcium.

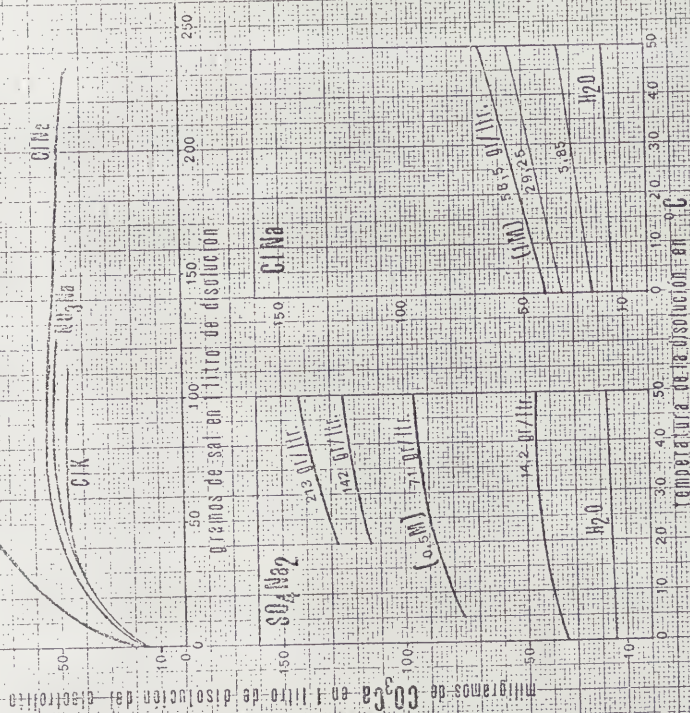
Nos résultats s'ajoutent plus haut, que nous avons exposés à la bibliographie publiée entre 1906 et 1952, prouvant que nous des variations trop larges. C'est pourquoi nous nous sommes mis à faire de nouvelles déterminations, en contrôlant avec le plus grand soin les principales variables qui affectent ces équivalents.

Les produits chimiques utilisés sont toujours de la qualité Merck et l'eau désionisée est suffisamment libérée des gaz. Les déterminations de carbonate de calcium solubilisé ont été effectuées à partir des données analytiques obtenues par trois méthodes employées en parallèle, à savoir: a) la détermination de Ca^{2+} par spectrophotométrie d'absorption atomique, b) l'évaluation de Ca^{2+} par complexométrie avec la Calceïne comme indicateur, c) la volumétrie avec ClH , en déterminant le point final avec un pH-mètre.

Pour les déterminations avec de la poudre de marbre et des calcaires, nous avons pu vérifier la grande influence qu'exerce la taille des particules; l'homogénéité et la constance des résultats est obtenue en broyant ces matériaux en fins particules dans un mortier en agate, jusqu'à ce qu'on obtienne la même finesse que celle des réactifs Merck. Dans ces conditions, les valeurs obtenues sont les mêmes que celles qu'on a lues pour les produits chimiques.

En dépit des précautions qui ont été prises, les résultats expérimentaux diffèrent légèrement les uns des autres; c'est pourquoi nous nous sommes mis à faire de nombreuses expériences, dont les résultats moyens figurent sur les diagrammes ci-joints (figure 2, abc.). Il est ainsi plus facile de les interpréter et de les comparer.

On remarque que la solubilité augmente quand la température



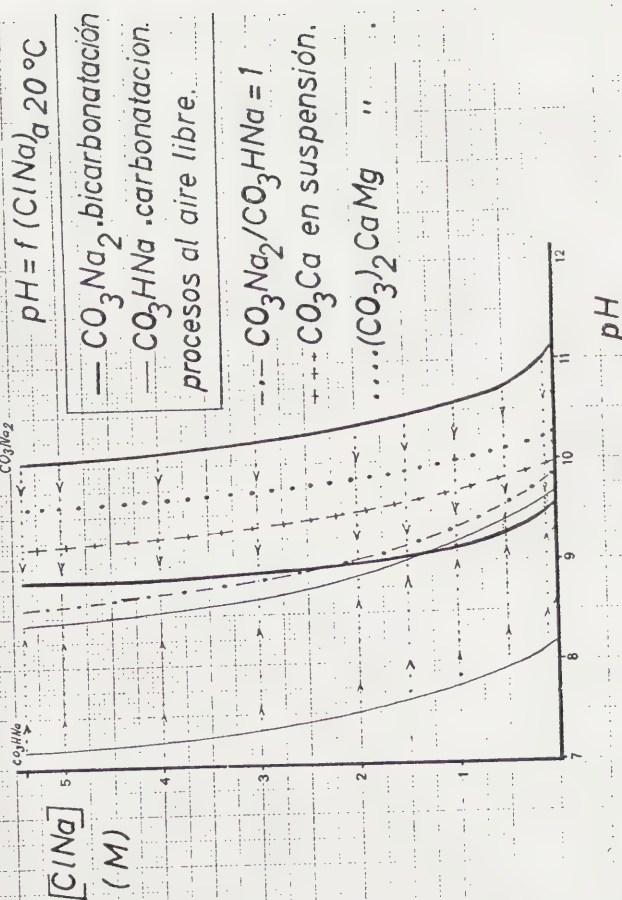
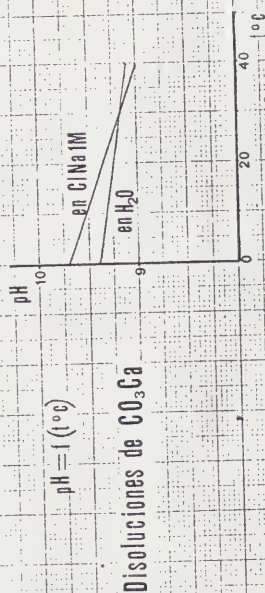
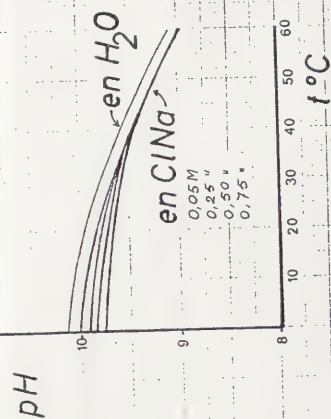
ture augmente et qu'elle augmente aussi quand s'accroît la concentration de sels, jusqu'à atteindre un maximum situé à peu près à 1,5 N. A partir de ce maximum, elle se stabilise et ensuite décroît légèrement. Les valeurs les plus hautes atteintes pour la solubilité du Carbonate de Calcium sont obtenues avec des solutions de SO_4Na_2 , de telle manière qu'avec une concentration 1,5M du sel, se dissolvent 0,14 gr. de CO_3Ca par litre; cette quantité atteint presque le double de celle qui correspond à l'action du CO_2 atmosphérique à la pression partielle normale(13). Pour le ClNa , le NO_3Na et le ClK , les activités sont décroissantes quant à l'augmentation de solubilité qu'ils produisent pour le CO_3Ca ; pour le ClNa 1,5 M, la solubilité est de 0,035 gr. par litre.

En conformité avec les valeurs qui figurent sur les graphiques de la fig. 2, nous résumons les points les plus significatifs en ce qui concerne la concentration et la nature des sels par rapport aux valeurs de la solubilité du CO_3Ca en gr./litre et par rapport aux relations de solubilité entre le CO_3Ca et les sels exprimées en poids équivalents, pour une température de 25°C.

(13) Catalán Lafuente, J. "Química del agua" Edt. Blume, Madrid (1968) p. 153.

Il reprend la courbe dessinée par Schmitt $\text{Ca}^{2+} = f(\text{pH})$ en même temps que les courbes de solution du carbonate de calcium. On voit que les eaux naturelles de surface en absence de phénomènes biologiques secondaires et quand il s'y trouve assez d'ions de calcium dissous - tendent à être en équilibre avec le CO_2 atmosphérique, tout en ayant tendance à avoir un potentiel d'hydrogène compris entre 6,2 et 8,4 et une teneur en ions de calcium compris entre 25 et 50 mg/l.

$\text{pH} = f(t^\circ\text{C})$
Suspensiones de CO_3Ca



Solubilidades en gr./litr. (a 25°C)

	En equil. con				
	H ₂ O	CO ₂ atmos. (pH = 8,2-8,4) ⁽¹³⁾	ClNa	SO ₄ Na ₂ 1M.	SO ₄ Na ₂ 1M.
CO ₃ Ca	0,013	0,075	0,025	0,055	0,117
(CO ₃) ₂ CaMg	0,014	-	0,025	0,05	-

Relaciones de solubilidad en Pesos Equivalentes (25°C)

	/sal 0,1N	/0,25N	/0,5N	/1N	/1,5N
CO ₃ Ca/SO ₄ Na ₂	7x10 ⁻³	4x10 ⁻³	3x10 ⁻³	2x10 ⁻³	1,5x10 ⁻³
CO ₃ Ca/ClNa	5x10 ⁻³	3x10 ⁻³	2x10 ⁻³	1x10 ⁻³	0,5x10 ⁻³
CO ₃ Ca/ClK	5x10 ⁻³	3x10 ⁻³	2,0x10 ⁻³	1x10 ⁻³	0,5x10 ⁻³

Potentiel d'Hydrogene des solutions et equilibre Carbonate/Bicarbonate.

Le pH des solutions de Carbonate de Calcium diminue avec la température et augmente avec la concentration de sels (f.3b).

Lorsque nous mesurons le pH de suspensions de CO₃Ca (3a), on constate une grande élévation dans l'eau, jusqu'à 10,5 à 0°C; cette valeur diminue quand il augmente la concentration de sels.

Pour interpréter ces résultats de façon quantitative, nous nous sommes mis à évaluer les solutions avec ClH 0,033 N, en nous fondant sur les considérations générales suivantes:

1° Dans le système protolytique de l'acide carbonique, les valeurs de pK₁ et de pK₂ sont respectivement 6,4 et 10,3; en représentant les concentrations de CO₃H₂, CO₃H⁻ et CO₃⁼, qui se trouvent en solution, comme une fonction du pH du milieu, il doit exister une symétrie en relation avec l'axe de pH en 8,4, valeur

Valoración de 0,2 mEq. de CO_3Na_2 en 150 ml. de disolución
utilizando ClH 0,033N (gasto total medio 6,05 ml. de ClH).

t 20	en AGUA		en ClNa										en SO_4Na_2					
			0,1 M		0,5 M		1 M		2 M		4 M		0,05 M		0,1 M		0,5 M	
	pH	ΔV	pH	ΔV	pH	ΔV	pH	ΔV	pH	ΔV	pH	ΔV	pH	ΔV	pH	ΔV	pH	ΔV
0	11,0	0	10,7	0	10,6	0	10,2	0	10,1	0	10,1	0	10,7	0	10,6	0	-	-
6	10,7	0	10,6	0	10,4	0	10,0	0	9,9	0,10	-	-	10,6	0	10,5	0	10,3	0
10	10,6	0	-	-	10,3	0	-	-	-	-	-	-	10,5	0	10,4	0	-	-
14	10,5	0	10,4	0,10	10,1	0,15	10,0	0,20	-	-	-	-	10,4	0,10	10,3	0,15	10,2	0,20
24	10,4	0,10	10,3	0,20	10,0	0,30	9,9	0,40	9,8	0,45	9,6	0,75	10,3	0,25	10,2	0,20	10,0	0,45
34	10,1	0,20	-	-	-	-	-	-	-	-	-	-	10,0	0,35	9,9	0,35	-	-
40	-	-	9,9	0,50	9,7	0,55	9,6	0,70	9,5	0,85	-	-	9,8	0,35	-	-	-	-
50	9,8	0,50	9,7	0,60	9,5	0,75	9,3	1,00	9,2	1,15	9,2	1,60	9,7	0,45	9,6	0,50	-	-
60.	9,6	0,60	-	-	-	-	-	-	-	-	-	-	9,5	0,80	9,5	0,80	-	-

qui est le demi-somme des logarithmes de K_1 et de K_2 ($pH = 1/2 (pK_1 + pK_2) = 8,4$) et qui correspond au maximum de concentration de CO_3^{2-} . Pour le Carbonate de Calcium, on établit que $[Ca^{2+}] [CO_3^{2-}] = 0,5 \times 10^{-8} = 10^{-8,4}$. Les points d'équivalence s'établissent en 8,3 et en 4,2 tout en sachant qu'il y a une marge d'incertitude. On détermine a priori les concentrations extraordinaires causées par les différentes solutions salines par rapport au ClH 0,033 N employé pour évaluer.

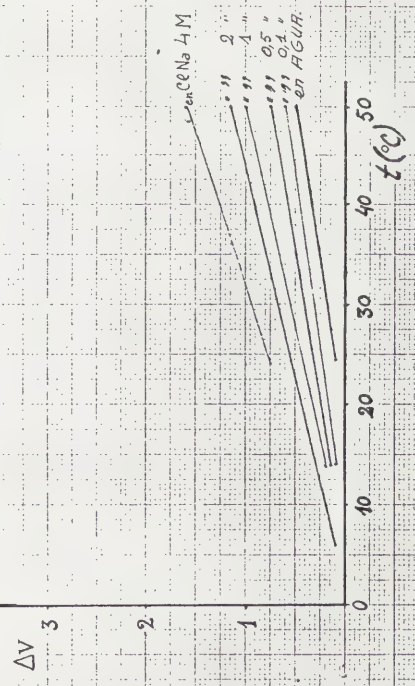
2) Pour établir les corrélations voulues, les éléments de comparaison nous sont fournis par les évaluations, dans 150 ml, des différentes solutions salines, de 0,2 mEq. de CO_3Na_2 . Pour les calculs qui s'avèrent nécessaires, nous appelons V_1 les ml. de solution acide qu'il faut pour arriver à ce que $pH = 8,3$, et nous appelons V_2 les ml. de solution acide qu'il faut pour arriver du pH 8,3 à $pH = 4,2$. Dans les expériences, nous observons qu'à mesure que la température augmente ou que quand la concentration des sels est accrue, V_2 devient plus grand que V_1 . Dès lors, cette différence ΔV doit correspondre à une quantité croissante d'ions Bicarbonate dans la solution. Sur le tableau ci-joint (fig.) les valeurs du pH et de ΔV apparaissent comme étant fonctions de la température et de la concentration de sel dans les solutions. La représentation graphique $\Delta V = f(t^{\circ}C)$ pour différentes concentrations salines, nous fournit les graphiques de la fig. .

L'évaluation des dissolutions de CO_3Ca (150ml.) dans l'eau et dans le ClH 1M avec ClH 0,033N pour différentes températures, nous apporte les données suivantes:

t°C	en H ₂ O				en ClH 1M			
	pH	V ₁	V ₂	ΔV	pH	V ₁	V ₂	ΔV
0	8,4	0,20	1,10	0,90	9,7	1,70	2,55	0,85
10	8,3	0,25	1,15	0,90	9,6	1,70	2,55	0,85
15	8,2	0,30	1,25	0,95	9,4	1,55	2,75	1,20

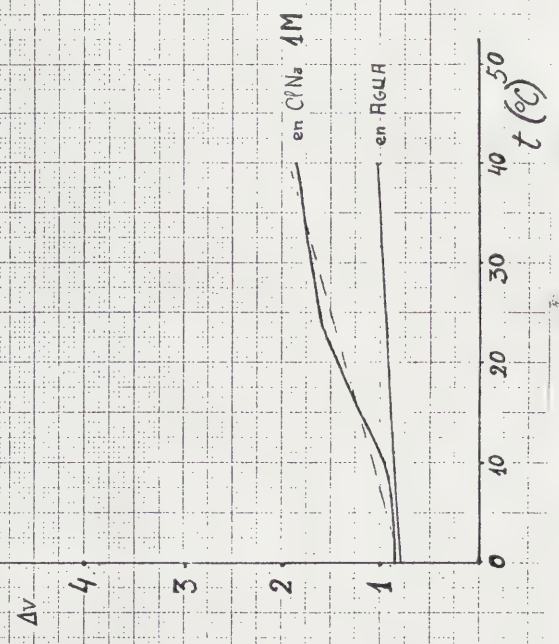
(V.M.) = 6.05 ml.

Valoracion de 0,2 mEq. de CO_3Na_2 con ClH 0,033N



Valoracion de disoluciones de CO_3Ca (iso ml.)

con ClH 0,033N









REPORT OF THE WORKING GROUP ON THE CARE OF WORKS OF ART IN TRANSIT.

Coordinator Nathan Stolor
with contributions from Bo Wennberg,
and Peter Cannon-Brookes.

ICOM Committee for Conservation
Madrid, 1-8 October 1972

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Remarks on the Program of the Working Group.

Nathan Stolow,
Coordinator.

At the Amsterdam meeting of the ICOM Committee on Conservation 15-19 September 1969 the working group and the program presented were as follows:

N. Stolow (Canada) co-ordinator	G. Thomson (U.K.)
R. D. Buck (U.S.A.)	K. Toishi (Japan)
N. S. Bromelle (U.K.)	D. Vance (U.S.A.)
B. Heimberg (Fed. Rep. of Germany)	F. D. Bo Wennberg (Sweden)
B. L. Marconi (Poland)	

1. To continue research into the design and manufacture of a small portable recording unit which may be placed in packing cases for travelling exhibitions to give continuous records of temperature, relative humidity, pressure, shock and vibrations. (Toishi, Thomson, Marconi).
2. To continue the study of changes in the physical (surface) condition of works of art in travelling exhibitions by means of the photographic enlargement technique of small selected areas. The previously studied Swedish exhibition will be re-studied after an extended period of time by the same methods to determine any further changes. The technique of photographic examination will be extended to larger surface areas of paintings to establish more clearly, e.g. the extent of craquelure changes. Further studies on supposed very fragile works, e.g., pastels, may be carried out in the same manner (Bo Wennberg).
3. To develop complimentary or independent (ref. 2, above) methods for recording changes in physical condition of works under travel conditions (Heimberg, Stolow).
4. To develop improved documentation systems (condition reports) relating to the assessment of the physical condition of works of art, particularly to devise an internationally acceptable set of descriptive terms for describing changes in the condition of works of art on loan (Buck, Vance).
5. To communicate and exchange relevant results and reports of the studies of this working group with other Committees such as the Committee on International Exhibitions.

Within the framework of the General Assembly meetings of ICOM in Paris and Grenoble 1971 a special meeting was held of the Conservation Committee and the Committee for Exhibitions. This meeting was held in Paris on 1 September 1971. The following is the report of this meeting as published in ICOM News December 1971:

Present: Mr. Ainaud de Lasarte (Spain), Mr. Andhare (India), Miss Bergeon, Miss Bizot, Miss Brans, Mr. Boissonas (France), Mr. Cadorin (Switzerland), Mr. Conron (United Kingdom), Mrs. Danilova (U.S.S.R.), Mr. Dawodu (Nigeria), Mrs. Delbourgo (France), Mr. de Vries (Netherlands), Mr. de Guichen (Rome Centre), Mr. Diop (Senegal), Mr. Havel (France), Mrs. Hours (France), Mr. Hubbard (Canada), Mr. Jaton (France), Mrs. Jouan (France), Mr. Lahanier (France), Mr. Landais (France), Mr. Lodewijks (Netherlands), Miss Mâle (France), Mr. Organ (United States), Mr. Philippot (Rome Centre), N. Stolow (Canada), Mr. Van Asperen (Netherlands), Miss Van den Bosch (Netherlands), Mrs. Vertogradova (U.S.S.R.), Mr. Van Schendel (Netherlands), Mr. Wennberg (Sweden), Mr. Wolters (G.F.R.) and Sir Philip Hendy (United Kingdom).

The purpose of the meeting was to re-examine the conditions under which ICOM normally agreed to give its official patronage to exhibitions, as so many complaints had been received following the return of objects loaned to such exhibitions in a more or less damaged state. There was a lengthy discussion on the administrative and technical aspects of the loaning and transport of works of art, which led to a realisation of the extreme complexity of the problem and of the inadequacy of the information available on the subject at the present time, and it was decided as a result that the following two resolutions would be moved for adoption by the General Assembly of ICOM:

"1. While it is recognised that international exhibitions are one of the major forms of cultural exchange, there is permanent danger of serious damage to works of art and objects of historical interest, owing to conditions of transport or variations in the atmospheric conditions in museums.

"It is felt, therefore, that there is a need for stricter control of the technical and administrative conditions under which objects are conserved and it is recommended that a joint working party undertake research with a view to the establishment of systems of documentation on these problems which will be in line with an accurate definition of the standards to be adopted in connection with exhibition environment.

"It is further recommended that the standards established by the said working party be made a part of the criteria governing the granting of ICOM patronage to international exhibitions.

It was also decided that Miss I. Bizot and Mr. J. Ainaud de Lasarte, representing the Exhibitions Committee, would be asked to join the Conservation Committee's working party on the transport of works of art — the coordinator of which is Mr. Stolow — so as to be in charge of the study provided for in the first of the above resolutions.

This resolution adopted by the joint committees reflected the very great need for further studies and actions to be taken in the field of care of exhibitions during travel. Your coordinator spoke at some length on this subject and there was a lively discussion following this in which museum directors, curators, conservators, and scientists participated.

The 10th General Assembly of ICOM adopted a more general resolution based on the above subject — described as Resolution No. 6. This gives considerable support to the program of the Working Group on the Care of Works of Art in Transit. Resolution No. 6. reads as follows:

ICOM,

recognizing that loan exhibitions bringing together works of art and museum objects have a vitally important educational influence throughout the world but that it is equally important to preserve and protect those works and objects at all times from damage or deterioration,

noting the efforts of the museum profession, within the limits of its knowledge and resources, to ensure that objects do not suffer when included in such exhibitions,

expressing concern at the increasing frequency of exhibitions and the consequent increase in damage caused to objects by poor packing, clumsy handling, shock and vibration in transit, violent variations in climate and lack of accompanying professional personnel,

resolves that in order to aid and assist those responsible for the execution of the necessary procedures, ICOM undertake through its relevant Committees the detailed study of all the desirable administrative and technical control factors significant for the improvement of the care and preservation of works of art and museum objects entrusted to international loan exhibitions.

In view of the adoption of the resolution in the joint committee meetings, and most significantly Resolution No. 6 General Assembly of ICOM, it will be necessary to revise the program and membership of the working group on the care of works of art in transit. Your coordinator will make firm proposals in this regard at the Madrid Meeting.

The present report includes four papers. The first refers to the transport of a panel painting by Simone Martini from Ottawa to Expo '70 (Osaka); the second and third papers discusses experiences in Sweden on transport of a Rembrandt painting to Amsterdam; and the hazards in shipping pastel paintings; and the third is a report from Birmingham, England on the transport of a British exhibition to Czechoslovakia and Austria.

Environmental Control during Transport of an Early Italian Painting from Canada to Japan.

by Dr. Nathan Stollow,
Director,
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National Museums of Canada,
Ottawa, Canada K1A 0M8.

One of Canada's national treasures, a 14th century painting by Simone Martini of Siena Saint Catherine was loaned for exhibition at Expo 70 in Osaka, Japan from 15 March - 13 September 1970. The painting, tempera on wood, dates to about 1320, and is from the collection of the National Gallery of Canada (1) was loaned the Fine Arts Museum at Expo '70 where it was to be part of an international exhibition of art treasures from around the world.

While the Expo '70 building to house the exhibition was to meet acceptable specifications as regards humidity, temperature, and human load factors (2), the loan of this very fragile and humidity sensitive panel painting would experience physical hazards at many points during its transit from Ottawa to Osaka. The painting itself had been protected in a sealed metal and glass case since its acquisition in 1956, and the inside RH kept reasonably within the limits of 40-50%. Under such conditions the painting was observed to be dimensionally stable and physically secure.

In order to ensure maximum safety and a constant environment for the painting it was considered necessary (a) to devise a new case with built-in humidity control, (b) to design a very effective packing system, and (c) to accompany the shipment with qualified personnel.

The case design and packing system, and specifications for the transit were developed and supervised by the author. He accompanied the shipment on the way to Japan, and his colleague Mr. Mervyn Ruggles came back to Canada with it following through with the same specifications.

LOAN AGREEMENT

The following conditions were attached to the loan agreement acceptable to the Japanese authorities responsible for the international exhibition at Expo '70.

- a) "the painting to be personally accompanied to Osaka with every possible assistance from the EXPO '70 officials to facilitate easy customs clearance at Tokyo airport and travel assistance to Osaka.
- b) "that the packing case not be opened except under the authority and supervision of the accompanying official.
- c) "that the exhibition gallery in which the painting is to hang will be controlled to a level of 50% relative humidity and 20°C. on a 24-hour basis. Also that the director of the art gallery in question give the necessary assurance by means of test records that the environmental controls do indeed work in the art gallery to the levels required, and will continue to work to the same levels.
- d) "a condition report prior to packing together with supporting photographs will be available and produced for inspection by the accompanying official. Copies of this report will be available for the records of the borrowing institution.
- e) "that the accompanying official be permitted to recommend a specific hanging area other than that proposed if the environmental conditions, e.g., relative humidity, temperature, and lighting are detrimental to the painting.
- f) "that photography, television and filming generally prohibited except under controlled conditions specified by the accompanying official. Generally, these conditions will specify control of temperature and intensity of light at or near the painting.
- g) "that the conservator in charge of the EXPO Art Gallery keep the National Gallery immediately informed of any change in condition of the painting during the period of exhibition, forwarding if necessary detailed photographs.

THE HUMIDITY-CONTROLLED CASE CONTAINING THE PANEL PAINTING

It was considered necessary to redesign the metal and glass case used since 1956 and incorporate some means for humidity control. It was decided to use preconditioned silica gel, successfully employed before within sealed cases (3). The description of this is given in Figure 1. The silica gel 'panel' referred to (described in greater detail in Figure 2) consists of Silica gel, 3-8 mesh size, pre-conditioned to contain 29.5% moisture, which corresponds to 55% RH, placed in a honeycomb aluminium construction covered front and back with cotton fabric. The silica gel panel made up in this manner was weighed along with the painting itself before sealing into the case. The cork separator, was to space the back of the painting a small distance away from the silica gel panel. To ensure

as air-tight a fit as possible a rubber gasket was fitted onto the metal flange of the welded aluminium case and a mating metal frame was bolted into position over the 1/4 inch plexiglass used as glazing. Glass was rejected in this instance because of its fragility. The sealed painting was then fitted into the box frame with shock absorbers and provision for hanging.

Data regarding the stability of the case:

1. The weight of the silica gel panel (pre-conditioned) prior to shipment (moisture content 29.5%, i.e., 53% R.H. potential). 18 February 1970..... 3639 gm.
2. The weight of the panel painting 18 February 1970..... 4985 gm.
3. The weight of silica gel panel 30 September 1970 after return from Osaka to Ottawa..... 3635 gm.
4. The weight of the panel painting 30 September 1970 after return from Osaka to Ottawa..... 4983 gm.

These data show that there was no appreciable loss of moisture from either the silica gel or from the panel painting. The RH environment was indeed very constant 53-50% RH during the entire 6-1/2 month period of travel and exhibition.

THE PACKING OF THE SEALED PAINTING

The method of packing is illustrated in Figure 3. The box is constructed from pinewood and mahogany plywood covered on the exterior with a tough impermeable 'skin' of polyester and fibreglass. Lining the inside of the case are sheets of 2 inch expanded polystyrene which serve as a temperature insulator. Following this is an envelope of heavy gauge polyethylene sheeting with sufficient material for heat sealing once the painting case is in position. Shock absorbers of fairly stiff rubber are placed at the four corners on the sides and bottom to accommodate shocks in all directions. The painting in its sealed case is lowered in the box and the exposed ends of the polyethylene sheeting are heat sealed so as form a closed envelope. The top level of polystyrene plastic is then placed in position (as in Figure 4), and finally the lid is screwed down onto the rubber gasketed edging of the box.

To facilitate handling of the packed box, now weighing 96 lbs. and of dimensions 45" high x 30" wide x 9" deep, a specially designed wheel base was constructed fastened by sturdy straps (shown in Figure 5). Thus the accompanying official could if necessary wheel the case by himself at junction points during the transit to Japan or return.

CONDITIONS DURING TRAVEL

The painting case was personally accompanied Ottawa-Vancouver in the first class compartment of a Boeing 727. The case was strapped into position vertically behind the last seats of the first class section taking precautions to place shock absorbers at the floor just under the case before attaching straps to the floor rings. A forward lurch could be accommodated by the soft chair back. On the connecting flight Vancouver-Tokyo, the cabin arrangements were different since the plane was a DC-8. The case was fixed vertically into position in the back of the tourist section of the plane in a box-like enclosure attached to floor-rings, and within this box straps were adjusted in different directions to retain the case and shock-absorb it at the same time. Temperature and relative humidity readings were taken at various points of the flight from Ottawa-Vancouver-Tokyo. While the temperatures were normal, i.e., 65-70°F, the relative humidity in the cabin was measured as 10% at 35,000 foot altitude. The fact that the packing case was quite air-tight and that the metal case containing the painting was also air-tight - minimized very greatly the possibility of replacement of conditioned air by cabin air of such low humidity each time the plane landed. (At high altitudes - lower cabin pressure - packing cases 'exhale' air - at sea level dry cabin air is 'inhaled' into the cases thereby affecting the painting). The total flying time was approximately 15 hours.

After an overnight storage in Tokyo airport under controlled conditions the case was transferred to the Tokyo-Osaka flight (one hour) and then by specially outfitted truck (designed for art transport) from Osaka airport to the Fine Arts Museum at Expo '70.

GENERAL CONCLUSIONS

The constancy in the weights of the panel painting and the accompanying pre-conditioned silica gel before and after the exhibition attest to the efficiency of relative humidity control. There was no noticeable physical change in the condition of the painting as judged by the study of very detailed condition photographs taken before shipment. The precautions taken in the case design and the method of packing paid dividends certainly. The environmental conditions in the exhibition gallery did not meet expectations. Crowds and variable climatic conditions in Osaka contributed to a fairly wide fluctuation in ambient relative humidity, i.e., 50-65% R.H.

In spite of such external variations the environment surrounding the Simone Martini painting was very stable throughout - attributable to sound design and construction principles.

REFERENCES & NOTES

1. Simone Martini (1280/5 - 1344) Saint Catherine. Tempera on gilded panel, arched, 83.2 x 40.6 cm (32-3/4 x 16 in); painted about 1320; National Gallery of Canada, Ottawa, Acc. no. 6430.
2. Many of the technical conditions for the building at Expo '70 were based on those for Expo '67 (Montreal) and detailed in: Stolow, N. The Technical Organization of an International Art Exhibition. Museum XXI (1968): pp. 182-240.
3. Stolow, N. Fundamental Case Design for Humidity Sensitive Museum Collections. Museum News (Washington, D.C.), Vol. 44 (1966). Technical Supplement, pp. 45-52.

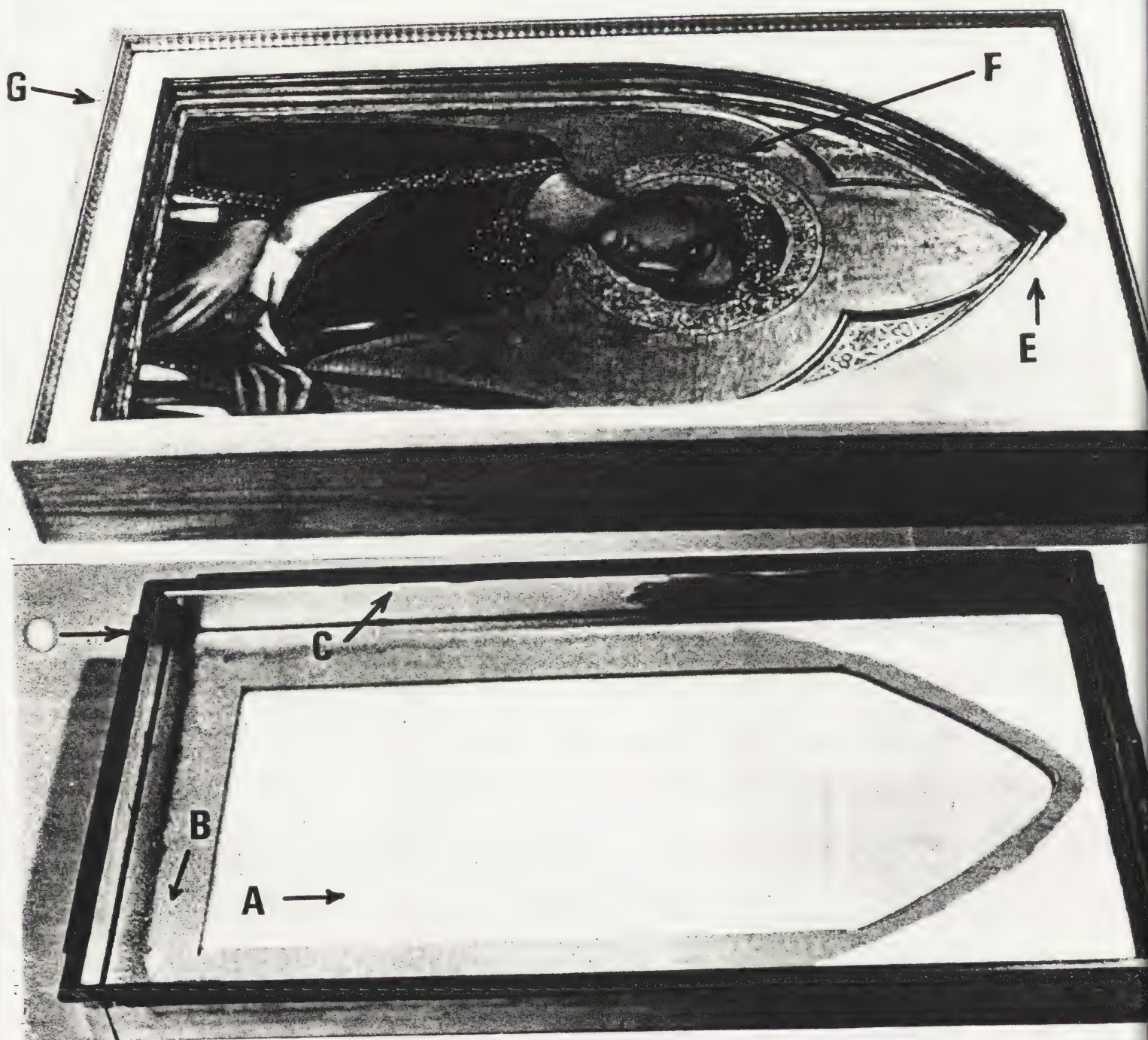


Figure 1. Transport of Simone Martini Saint Catherine to Expo '70. The humidity controlled case for the panel painting. A- silica gel panel conditioned to give RH of 50-55%. B- cork sheet separator. C- welded aluminium case with flange. D- flange with rubber gasketing. E- fabric covered surround to accommodate shape of panel painting. F- plexiglass clamped over gasket and flange (D). G- box frame.

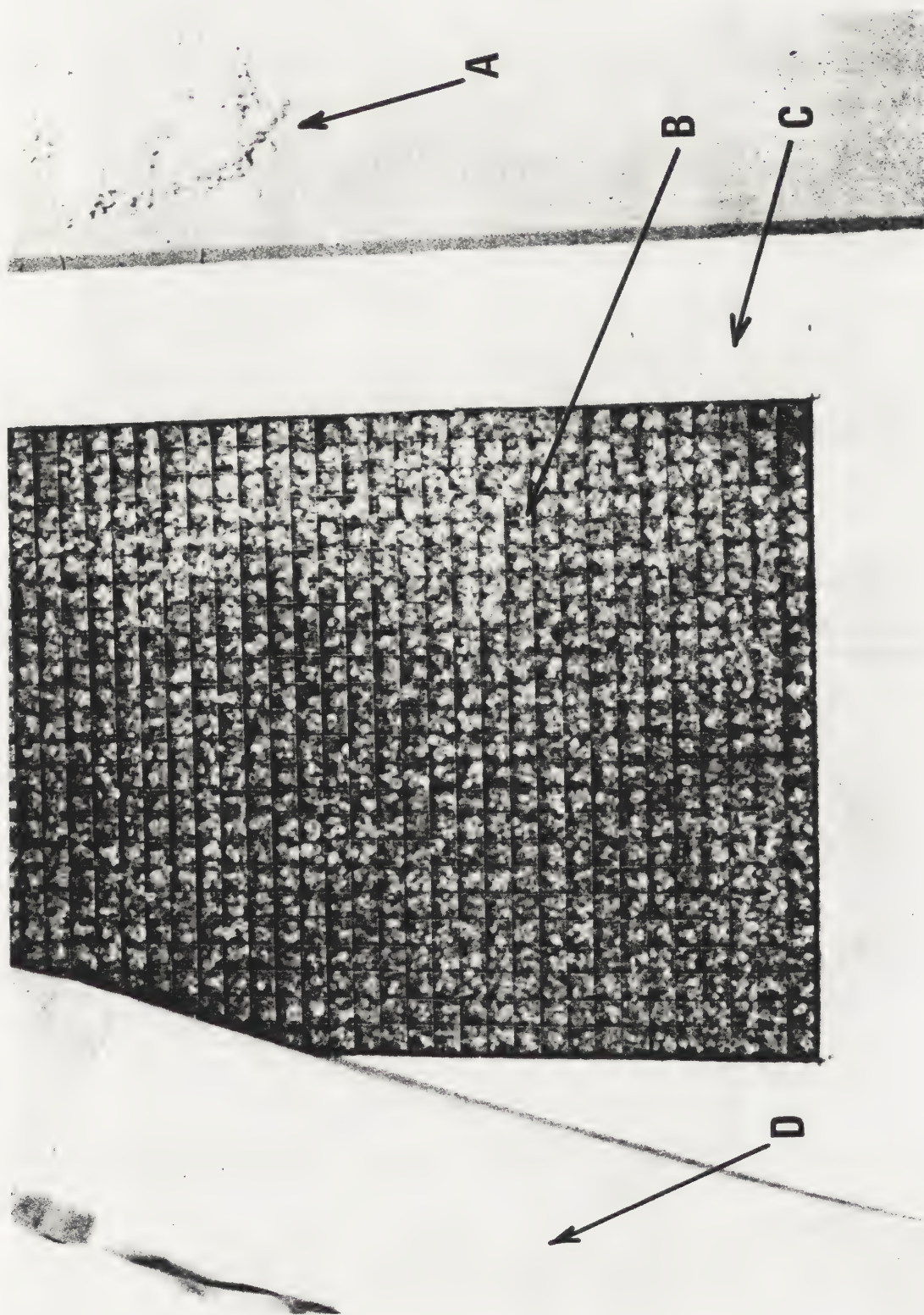


Figure 2. Detail of silica gel panel. A- silica gel pre-conditioned to give 50 -55% RH, 3-8 mesh size. B- honeycomb construction (aluminium) to retain the silica gel, C- outer frame of fibre board same thickness as the honeycomb. D- cotton fabric to cover over the silica gel panel.



Figure 3. Simone Martini Saint Catherine being packed in special case.

A- pine and plywood case with external fibreglass and polyester skin. B- expanded polystyrene insulation. C- polyethylene covering. D- pine and plywood case with external fibreglass and polyester skin. E- expanded polystyrene insulation. F- polyethylene covering.



Figure 4. The packing case with the top covering of expanded polystyrene in position before attaching the box lid. A rubber gasket around the edge of the case permits a very tight closure.

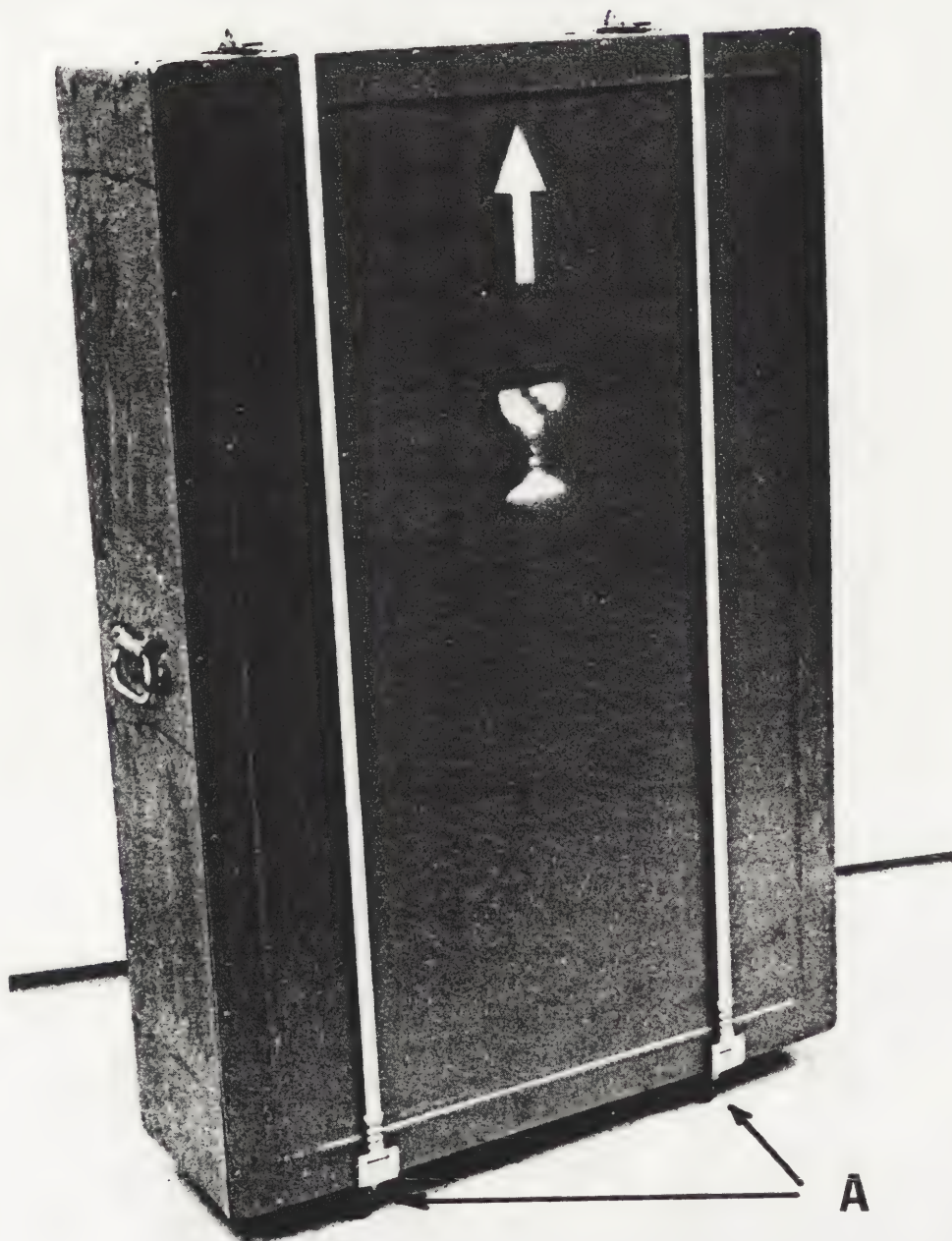


Figure 5. The packing case ready for shipment. A wheel base (A) is attached to facilitate handling and movement by the accompanying personnel.

The Evaluation of Damage to Paintings during Transport by Photographic Enlargement Studies.

by Dr. Bo Wennberg,
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and Sculptures,
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Stockholm, Sweden.

This report is a sequel to the "Preliminary study of Damage to Paintings during Transport and Temporary Exhibition by Means of Photography Enlargement, presented at the ICOM meeting in Amsterdam in 1969. That report proposed for future study the examination of larger areas of pictures by the same means of photographic enlargement as used in the first instance.

A most suitable object for study of large area had already at this time been chosen, i.e. the great painting by Rembrandt "Claudius Civilis", of which 19 different areas of the surface had been photographed before the transport to Amsterdam. Two of these areas, representing the faces of Claudius himself and the man in profile, are fairly large, resp. 17 x 13 and 15 x 10 cm. The 17 others scattered over the surface (see Figure 6) are all about 6 1/4 cm². (The photographs and all technical work connected with them executed by Christina French of the Photographic Department of the Nationalmuseum.)

The study of the photographs of the two faces ought to give a fairly good idea of the general extent of cracking or flaking which might have occurred during the transport and exhibition of the picture.

However none of the photographic enlargements, i.e., the 17 smaller areas nor of the two larger ones, show any recent damage after the return to Stockholm. Even slight tendencies to flaking which can be observed in some areas in the first set of photographs do not seem to have progressed further.

This is a surprising fact, compared to the results documented in the previous study, where damage was registered in 4 out of 25 pictures sent in 1968-69 on a travelling exhibition to the North of Sweden. It may be too early to draw conclusions from these different results, but it may be pointed out that the 25 pictures were handled in the normal way for such undertakings; they were taken well care of but not handled with exceptional precautions. The transport of the "Claudius Civilis" on the other hand was of course prepared with utmost care, cases made to measure, special transport van was used, and driving adjusted in order to reduce bumps and vibrations as much as possible.

As in the previous study it must be pointed out that these results are accurate only for the present condition of the painting. A repeated photographic study of the same areas, ought to take place in a couple of years time in order to see whether delayed deterioration or mechanical action has occurred.

Figure 6. Areas of photographic study of Rembrandt *Claudius Civilis* prior and after transport Stockholm-Amsterdam.



A Study of Pastels in Transport (1970-1971)

by Dr. Bo Wennberg,
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Stockholm, Sweden.

Traditionally pastels have been regarded as so fragile in consistence, that most museums refuse their lending and transportation. The author of this investigation, who has had some practical experience of working with the material, had the impression that the danger of moving pastels might be somewhat exaggerated in public opinion. It also seemed right to test in practice, what had hitherto been considered as a fact without conclusive proof.

This is the background to an investigation carried out by the Nationalmuseum, Stockholm, in 1970-1971.

A collection of 15 pastels was sent on a travelling exhibition October 31st, 1970 to February 9th, 1971 to Kalix, Arjeplog and Luleå in northern Sweden, and after their return to Stockholm to the suburb of Stockholm, Midsommarkransen, February 15th to March 23rd 1971, a total distance of near 2,700 kms. Although outer temperature was for a good deal of the distance below zero (Celsius), the special transport vans of Nationalmuseum and of the Luleå museum, the latter of which took care of the transports in the north, always kept an inner temperature well above zero. The relative humidity in the three exhibition places in the north varied between 40% (in Luleå) and 60% (in Kalix and Arjeplog). During the transport all the pastels were packed very carefully in wooden crates with a lining of foam rubber.

As in the earlier report to ICOM presented at the meeting of the Committee for Conservation in Amsterdam in 1969 the principle of examination applied was that of a photographing at great enlargement (macro-photography) small sections of each painting before the transport and after the return of the exhibition. This was carried out, but through unfortunate incidents only in a very incomplete way: three of the paintings were documented only in one place, five only in two places, the rest in three places (In the preceding investigation each painting had five spots photographed.).

However, care was also taken to control possible falling off of pastel paint by study of the covering glass. Before the transport each glass was carefully cleaned and the inner lining of the frames renewed.

After the return the glazing was removed and studied for traces of paint, as well as the linings. This second study gave very clear information. Not less than 8 pastels had shed quite visible quantities of colour on their glass, while the enlargements of the photographs failed in 6 of these instances to register any changes in the surface (which clearly shows the inadequacy of the photographic method). On the other hand the enlarged photographs showed small changes in the pastel surface in two instances where the coverglass did not show any loss of colour at all.

Although the photographs in this investigation were, as already pointed out, rather inadequate in number, they give together with the observation of the coverglasses a quite clear picture of what has happened to the pastels during this travelling exhibition, where they were exposed on purpose to the same kinds of stress that many oil paintings undergo as a routine without great hesitation in many museums.

One can sum up the results as follows

1. Out of 5 pastels from the 18th century 4 showed damages, two of them rather heavy loss of paint material on the glass.
2. Out of 4 pastels from the 19th century 3 showed damages in the form of paint on the glass, in two cases rather substantial ones.
3. Out of 6 pastels from the 20th century 3 showed damages, one a small damage in photoenlargement, two others in the form of paint on the glass. Of these latter one had lost a good deal of material and the enlargements showed rather distended changes in the paint surface.

CONCLUSION

The general conclusion of these facts should be 1) that no pastels, not even dating from this century, can be sent without strong risk of damages on a prolonged travelling exhibition, and 2) that it is clearly proved, that they are considerably more fragile than oil paintings. This result is obviously not surprising. However it still stands to see, whether the risks can be reasonably diminished by sending pastels under specially designed conditions, e.g. by airplane under controlled, secure cabin conditions to just one single exhibition. Here some experience with the change of air pressure would be needed before any definite conclusions can be made.

It should finally be pointed out, that even where terms such as "heavy loss of paint" are used, this does not mean, that one can perceive any visual changes in the pictures. They may appear quite unchanged to the naked eye.

APPENDIX

List of the pastels discussed above and indications of damage in each case.

av.nr in the Nationalmu- seum	Name of artist	Title	Century	Number of photo- graphs taken	Damage visible in photo- graphic enlarge- ment	Loss of paint visible on cover glass ! = rather heavy loss of paint
NMB						
1292	Gustaf Lundberg	Portrait of unknown middleaged Gentleman	18th	2	x	
307	Gustaf Lundberg	Mrs. Petro- nella Schüt- zer, née Psi- landerhjelm	18th	3	x	x!
1378	Gustaf Lundberg	Hedvig Ulrika Taube, Coun- tess von Hessenstein	18th	2		x
468	Carl Fredrik Richter	Portrait of a Lady	18th	2		
346	Johan Fredr. Hörling	General-Major Kristian Joakim Klingspor	18th	3	x!	x!
306	Frits Thaulow	Breaking-up the Ice	19th	1		x!
1484	Albert Edelfelt	Portrait of Mrs. Agnes Lamberg	19th	3		x
320	Egron Lundgren	Self-Portrait	19th	3		
1550	Robert Thegerström	Lady in a Straw Hat	19th	2		x!
1677	Lennart Rodhe	Abstract	20th	1		
1712	Rossander, Armand	Red Mountain	20th	1		
1737	Johannes Itten	Dark Vase	20th	2	x	
1206	Marcus Collin	Motif from Brittany	20th	3	x!	x!
109	Henning Malmström	Still Life Flowers	20th	3		x
1489	Einar Forseth	Söderåsen	20th	3		

TRANSPORTATION OF THE EXHIBITION "TWO CENTURIES OF BRITISH ART"
SHOWN IN PRAGUE, BRATISLAVA AND VIENNA, 1969

by Dr. Peter Cannon-Brookes,
Keeper, Department of Art,
City Museum and Art Gallery,
Birmingham, Great Britain.

In the summer of 1967 initial discussions took place between the British Council and the Czechoslovak Ministry of Culture in respect of the exhibition of British Art and it was proposed to send to Czechoslovakia in 1969 in accordance with the provisions of the Cultural Exchange Agreement between Great Britain and Czechoslovakia. The general outlines of this exhibition were agreed in Prague during mid-summer 1968 and the Czechoslovakia Ministry of Culture undertook to organize an exchange exhibition of Baroque art from Bohemia to be shown in London and Birmingham during the second half of 1969. In August 1968 the Warsaw Pact armies entered Czechoslovakia, and the final organization of this exhibition took place against a background of political uncertainty. This in turn affected the transportation of the exhibition in so much as it was deemed essential to specify that the specially fitted out trailers should remain in close proximity to the buildings housing the exhibition in Prague and Bratislava, and that considerably less expensive containers could thus not be used as these would have had to be stored in depots some distance from the exhibitions. In January 1969 it was decided to extend the tour of the exhibition in order to display certain of the oil paintings in the Hofburg, Vienna, as part of the British Week there. The British Council maintained overall responsibility and control of the exhibition, but the selection of the exhibits, their preparation and their transport were delegated to the City Museum and Art Gallery, Birmingham, which was the principal lender (a little over half the total number of exhibits).

The City Museum and Art Gallery, in 1969, possessed no department of conservation and no specialist trained art technicians, and thus the detailed control over packing and the design of the trailers were undertaken by the author as Keeper of the Department of Art. Whilst freely admitting such a situation to be far from ideal, the Department of Art had gained over previous years considerable experience in the organization and administration of international exhibitions, and Dr. Nathan Stolow's report on "Expo 67", together with his "Controlled Environment for Works of Art in Transit", were available to be used as the foundation for the planning. In consultation with Mr. Gary Thomson of the National Gallery, London, the author designed the packing described below to follow as closely as possible the theoretical proposals of Dr. Stolow, but on an empirical basis. It is impossible to make any estimate as to just how successful were the packing and the transportation techniques, but it can be

stated that no damage identified during the tour of the exhibition, or during the following three years, has been able to attributed to the conditions under which this exhibition was transported. However it must also be stated that the budget was of necessity limited and that the degree of insulation against violent changes in temperature and against physical shocks was carefully calculated in the light of the plan to supervise closely every stage of the transport.

PREPARATION OF THE EXHIBITS

The exhibition consisted of 166 items, comprising 85 oil paintings and 81 drawings and watercolours, and their framed sizes ranged from a series of full length portraits measuring around 2.80m by 2.20m to small oil sketches and watercolours 40cm or less. All the exhibits were assembled in Birmingham and those coming from the national and major provincial museums were in general prepared in their home museums and were transported to Birmingham lightly packed. Those paintings coming from private owners and small museums without the necessary technical services were packed lightly and transported to Birmingham to be prepared there, or were prepared in London by the workshop staff of the British Council Fine Arts Department before despatch to Birmingham. All works were inspected immediately on arrival in Birmingham and a condition report written into a bound volume which accompanied the exhibition on every stage of the tour.

With very few exceptions the oil paintings, and all the drawings and watercolours, were glazed in perspex (ultra-violet absorbing grade in the cases of the drawings and watercolours) and backed with sheets of high grade hardboard for protection, and the only damage known to have been sustained during transport was by a painting delivered to Birmingham already glazed and backed which was discovered, after it had broken loose, to have been inadequately attached within its rebate. Those works prepared in Birmingham were inspected again immediately before packing and the salient details were recorded in the condition report book.

PACKING

After preparation all the oil paintings were placed in light weight packing cases constructed of 20mm or 25mm softwood for the sides and timber framed plywood for the bottoms and lids. These had been made in advance and the internal measurements were intended to allow 25mm clearance round the frame in all directions. Corner pads of kraft paper

stuffed with wood wool allowed the frames to be held gently but firmly within the cases without further attachment or packing. Where the sizes of the frames of the paintings, as provided by their owners, proved inaccurate the internal dimensions of the case in question were able to be adjusted suitably using sheets of expanded polystyrene of different thicknesses cut to size. Good quality, well seasoned timber was employed throughout, and the cases and the packing materials were delivered to the City Museum and Art Gallery approximately 5 to 7 days in advance of packing to enable the materials to become "tempered" to the museum environment. The lack of proper humidity or temperature control in the City Museum and Art Gallery did not allow any more precise control to be achieved, but packing was undertaken in a large gallery which by previous tests had been demonstrated to be particularly stable in its conditions in early summer. The watercolours and drawings were wrapped in two layers of corrugated paper and placed in specially designed packing cases with wooden internal partitions. After packing the cases were held in store within the packing area until the trailers were loaded.

TRAILERS

Owing to the political uncertainties, the decision had been taken to pack the exhibition into two ten-metre trailers rather than to employ more economical containers which would have lacked the necessary flexibility in the event of an emergency. The two ten-metre trailers were fitted with an internal compartment or liner which was insulated from the outside aluminium skin by wood wool or expanded polystyrene sheeting. The floors of the liners were constructed of sheets of multi-ply and the whole liner rested on a mattress of rubberized hair 5 cm thick. Each liner was built in sections and, after the end wall of the trailer had been lined with sheets of expanded polystyrene 5cm thick, the end section was lifted up by a fork-lift truck and slid into the trailer. When in position the 5cm gap between the top of the liner and the ribs of the trailer roof was filled with further expanded polystyrene sheeting 5 cm thick, and the rather wider gaps between the sides of the liner and the sides of the trailer were stuffed with wood wool rammed tight. The remaining sections of the liners were inserted similarly, one at a time, and were locked together with long coach bolts. During the construction the bales of wood wool were broken open the day before use and the wood wool was spread out all over the floors of the workshop to avoid introducing any material that was either excessively dry or excessively damp. Unfortunately attempted spot tests carried out during construction were unhelpful, and, although on completion a spot test on the atmosphere within one container after remaining closed all night gave an R.H. reading which was acceptable, in the opinion of the author the figures so obtained cannot be relied upon, while he was advised that no satisfactory system of obtaining continuous records of the conditions within the trailers was available in 1969.

LOADING

The completed trailers were loaded with the light cases containing the paintings, and since the surfaces of the cases were basically flat it was possible to pack them in very tightly indeed, thus obviating any necessity to strap them to the walls of the liner. As the cases were inserted additional wood wool was rammed tight to fill the interstices, and close to the doors of the trailers wood blocks were screwed to the floors of the liners to prevent longitudinal slipping. Certain very large cases had a clearance of as little as 2/3cm, but this did not cause any difficulties since all the heavier cases were carried onto the tail-lift platform of a van normally used for computer transport and then lifted to the exact level of the floor of the liner, to be slid into it without problems. After loading was complete, stout wooden bars were screwed into position across the entrance of the liner, the framed end panel of perforated hardboard screwed into position, two large sheets of expanded polystyrene 5cm thick wedged into position and sheets of rubberized hair inserted between them and the doors to stabilize the load. The trailers were then locked and sealed by H.M. Customs, and remained undisturbed until their arrival in Prague.

TRANSIT AND UNLOADING

Three days were required to drive from Birmingham to Prague, with the first night spent on the ferry between Harwich and The Hook of Holland, and the second in the German autobahn police headquarters outside Aschaffenburg. Despite very bad road surfaces near The Hook of Holland and around Plzen, the packing remained in position and very little settling took place in the wood wool stuffed between the liners and the walls of the trailers. After unloading the loose wood wool was retained within the trailers and they were closed as quickly as possible, but after unpacking the exhibits all the packing materials were placed in their respective cases and, on reopening the trailers, all the cases were stored in them for the duration of the showing of the exhibition. Attempts were made to park the trailers where they would be out of the direct rays of the sun, but this was not on every occasion possible.

On subsequent stages of the exhibition tour the cases were packed, and the trailers loaded and unloaded, according to this plan, and the exhibition was split in Vienna when detailed administration of it was taken over completely by the British Council. During every stage the operations were supervised by curatorial staff from the City Museum and Art Gallery and by the staff of the Fine Arts Department of the British Council with condition reports prepared and entered into the

condition report book, and the escorts during transit limited the speed of the convoy suitably in order to minimize the effect of bad road surfaces.

GENERAL NOTES

1. 3,500 kg of wood wool was used for stuffing the sides of the trailers and for packing between the cases, giving a minimum of 1,750 kg of buffering material in each sealed trailer. The additional buffering effect of the timber used for the cases and the framing of the liners raises the total mass of buffering material to approximately 4,000 kg per container. Thus, the mass ratio of buffering material to humidity sensitive works of art, including their frames, can be estimated to have been almost 2:1.
2. The cost, in 1969, of fitting out the two trailers and providing the necessary light cases totalled £1,849 sterling which compared very favourably indeed with the estimated cost of providing orthodox single and double cases for the transportation of the exhibition. If, however, orthodox cases had been employed, at least one additional trailer would have been required, and the process of packing and unpacking would have occupied a great many more man-hours with considerably increased costs.

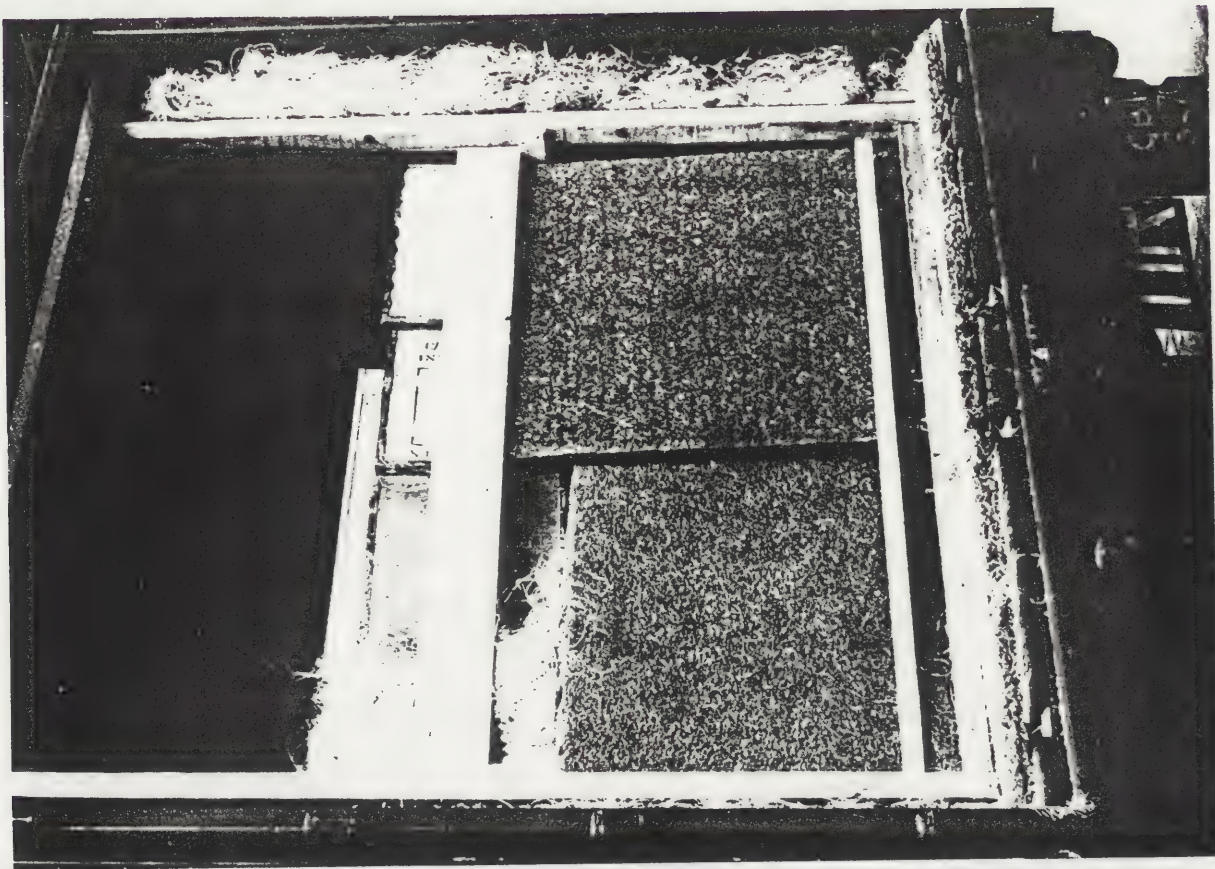
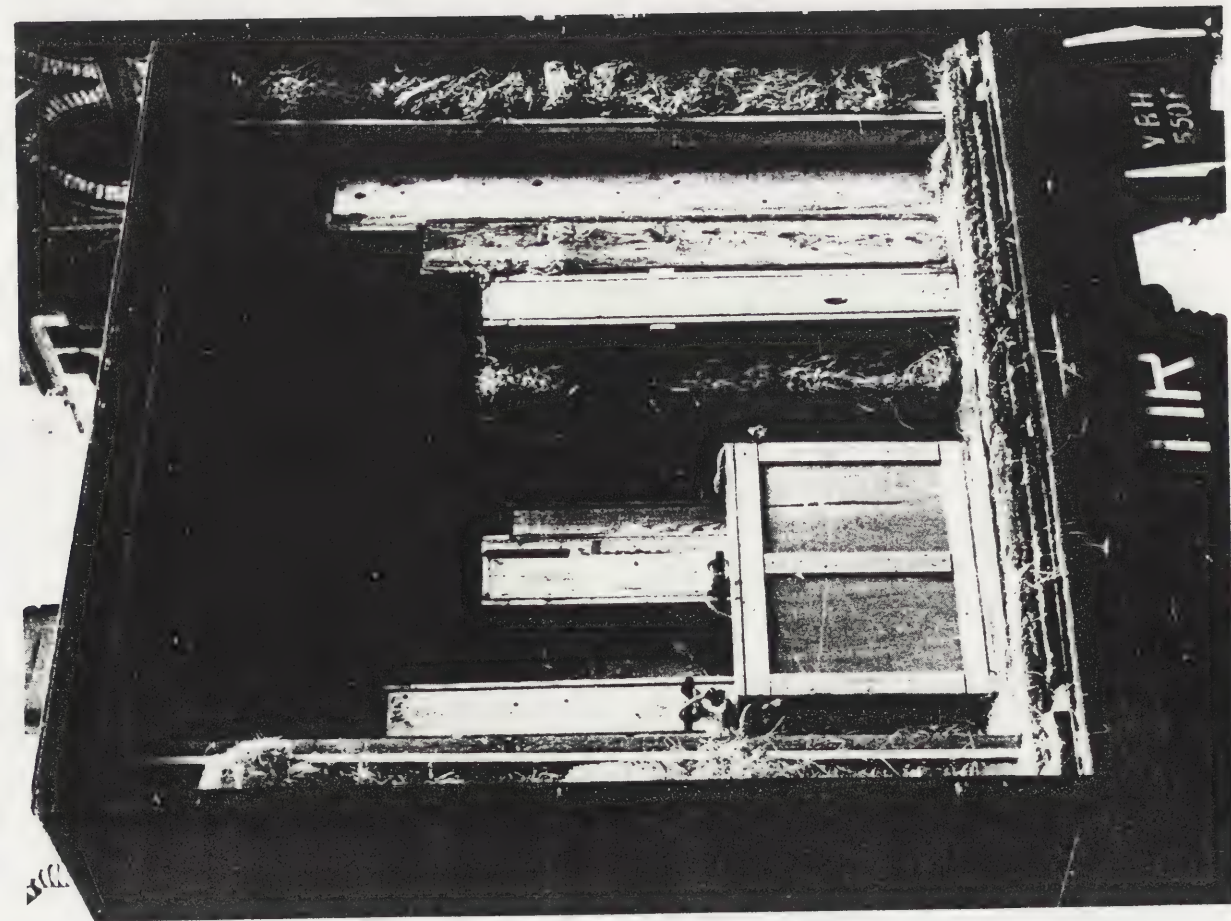


Figure 7. Trailer no. 1 nearing completion of loading of the cases. (left).

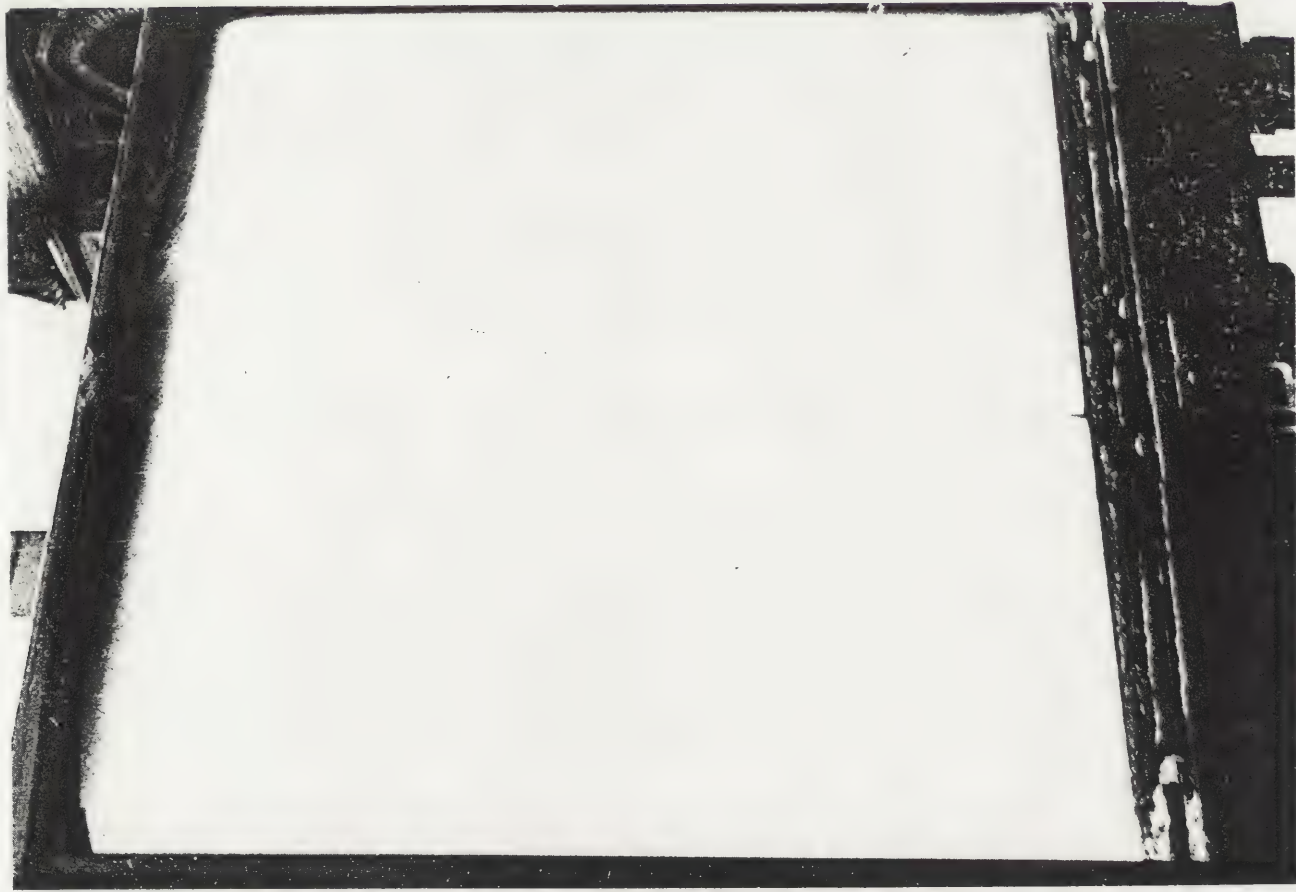
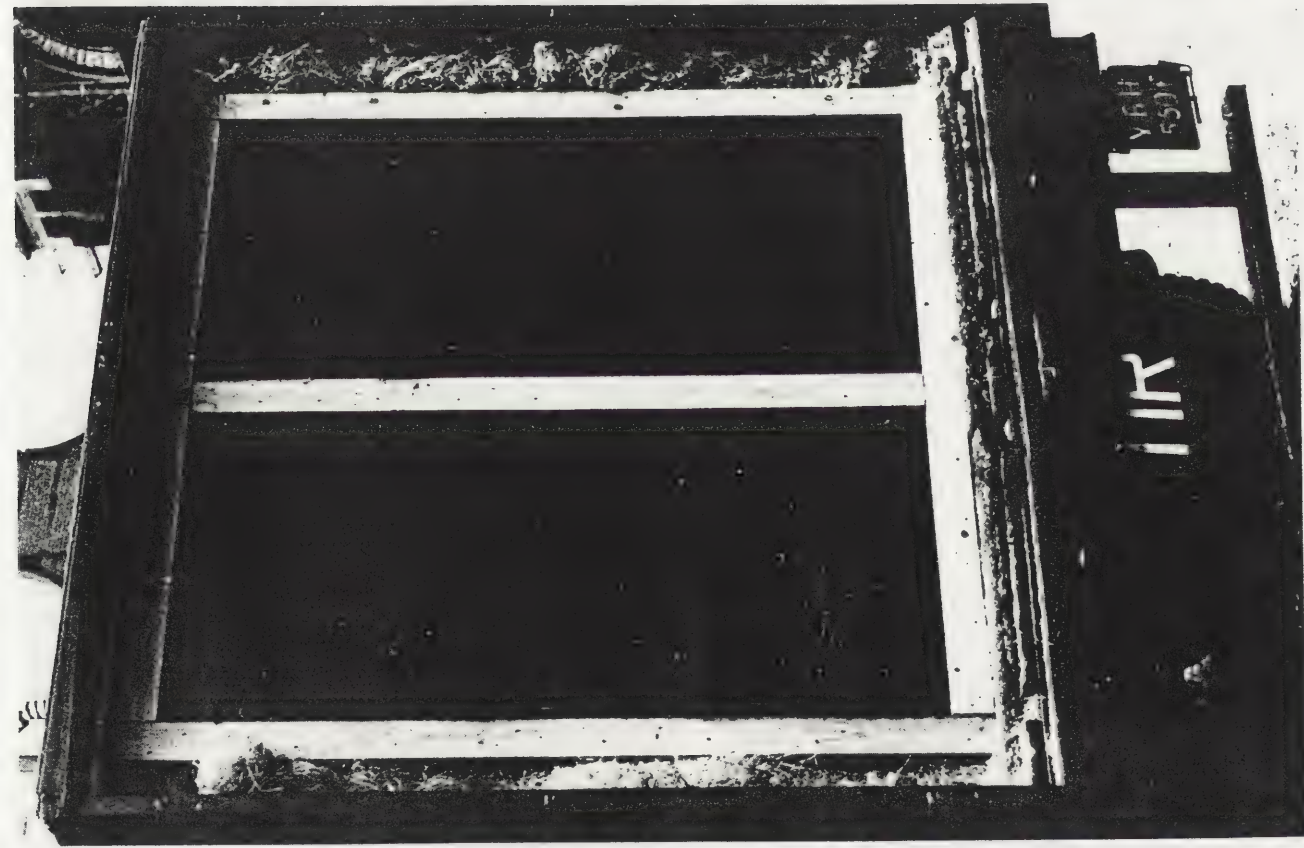
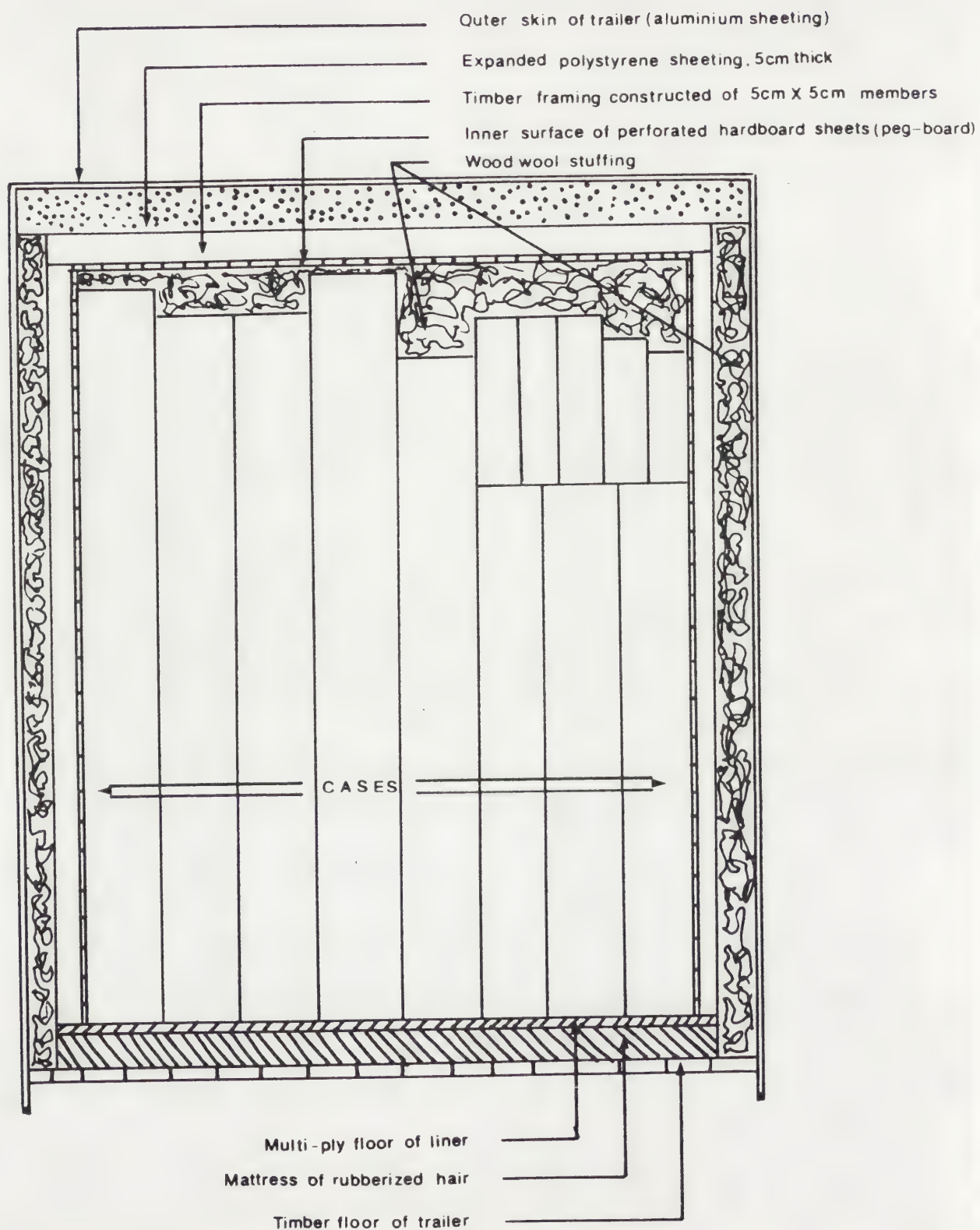


Figure 8. Trailer no. 1 with the framed end panel of perforated hardboard screwed into position (left), and the sheets of expanded polystyrene in position prior to closure and sealing (right).

SECTION THROUGH TRAILER: CONSTRUCTION AND PACKING



DRAWING NOT TO SCALE

Figure 9. Schematic drawing of section through trailer showing construction and method of packing.





Abstract

FRANZ MARINGER : FODAS AERO - TYPE 8443

FRANZ MARINGER

Le film infrarouge et couleur Kodak Aero 8443 donne des possibilités différentes pour l'examen des œuvres d'art. Etant donné que les teintes et les pigments présentent des caractéristiques d'absorption et de réflexion différentes dans l'infrarouge, on peut déterminer de manière approximative la nature des colorants sur les surfaces photographiées.

Le résultat actuel et la vision des possibilités se basent sur des recherches effectuées: - sur une série de planchettes en bois, recouvertes de préparations différentes; peintes avec des pigments sélectionnés et broyés avec différents liants; - sur l'hôtel de Hyeronimus Bosch de l'Académie de Vienne.

Cette méthode d'examen est encore au stade d'expérimentation; néanmoins on peut déjà pressumer les résultats futurs.

Vues dans des conditions de lumière normale, les couleurs se révèlent être parfois très différentes sur les diapositives de l'Aero. On arrive ainsi à distinguer des pigments différents et à déterminer, compte tenu de certains facteurs, l'étendue d'une peinture ou d'une retouche.

Le dessin préparatoire est bien rendu lisible, suivant les circonstances, mieux que sur des photos I.R. blanc et noir. D'après la couleur, ça semble être possible de déterminer le matériel employé, en tout cas de distinguer les différentes matières entre elles. Crayon, encre à écrire, encre à dessiner peuvent être différenciés, ce qui facilite la lecture de Papiri et Palimpsesti, comme cela a déjà été essayé à Vienne. Des photos Aero de coupes de couleurs permettront avec toute probabilité de différencier liants et vernis dans le cas de couches superposées; à condition que les compositions des couches soient différentes les unes des autres. Colles, résines, huiles et gommes de plantes ont des réflexions différentes.

Une aide à l'identification des bois est possible, montrant par Aero, par exemple, la différence entre Pins et Feuillus.

Il faut encore étendre cette méthode de recherche aux vitraux, émaux et glacis de la céramique.

En outre il semble possible d'employer ce film Aero dans le spectre de la fluorescence ultraviolet-violet, étant sensible jusqu'à 360 mμ longueur d'onde.

La recherche à l'aide du film Aero-Kodak donnera, dans une certaine mesure, des possibilités d'analyse de la matière de l'œuvre d'art sans toucher l'objet. Avant déjà pris des particules de matière, celles-ci peuvent être examinées sans, ni changer ni détruire l'échantillon tant valables. Ce dernier restera ainsi disponible pour d'autres examens dans les archives.

Les résultats des recherches confirment et élargissent ceux publiés par G.H. Olin et T.G. Carter sous le titre "Infrared Color Photography of painting materials" in "Technical papers from 1968 trough 1970" der I.I.C. American Group et par G. Wehls "Infrared Farbfilm" dans Maltechnik 1/1971.

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der bildenden Künste - Vienne -







The International Council of
Museums
Committee for Conservation

Conseil International des Musées
Comité pour la Conservation

Madrid: October 2-8, 1972

Bethune M. Gibson - Conservation Lab., Dept. of Anthropology,
Smithsonian Institution, Washington, D.C.
U.S.A.

MECHANICAL CLEANING OF ETHNOGRAPHIC MATERIALS
BY USE OF THE AIRBRASIVE PROCESS

The airbrasive process employs a system of grit spraying which is so refined and controlled that it may be used to drill a diamond or to dust a rice paper fan - entirely by the use of the appropriate abrasive, adjustment of the air pressure, adjustment of the flow of abrasive, and control of the nozzle-to-subject surface distance. It is therefore extremely useful in the mechanical cleaning of ethnographic specimens which are disfigured by corrosion products, mud, dust, and other types of loose, non-greasy dirt which may have accumulated during use, improper storage, or during exhibition where the objects were not protected by cases.

The Airbrasive unit consists of a metal cabinet basically containing a vibrator chamber which holds about .454 Kg. (1 pound) of abrasive powder and a rubber hose which carries air to the chamber from either a carbon dioxide cylinder or an air compressor. Another hose delivers the mixture of air and abrasive to a small nozzle at the end of a handpiece. The air pressure used on most objects may be anywhere between 2.8 and 5.6 kg/cm² (40 and 80 p.s.i.) depending on the nature of the work.

Abrasive powders which may be used are silicon carbide, aluminum oxide, calcium magnesium carbonate (dolomite), sodium carbonate,

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and glass beads (a powder consisting of minute glass spheres n. larger than 50 microns in size).

Silicon carbide is rarely used in our work because of its extreme hardness; aluminum oxide is sometimes employed to remove hard rust from iron, although its use causes excessive wear on the parts of the unit which come in direct contact with the abrasive flow; dolomite is most frequently used - perhaps 90% of our work is accomplished with it; sodium carbonate is not employed in our work, as we prefer glass-bead powder in its place. This powder is not properly an abrasive, as each particle is a sphere and has no cutting edges. It is primarily used for light polishing and cleaning very delicate materials or removing tarnish from silver and other soft metals.

The abrasive dust and detached corrosion particles are taken up by vacuum into a dust collector box. The abrasive is therefore not reusable.

The cost of the abrasives most frequently used is moderate. Dolomite and glass-bead powder are both about \$ 50 U.S. for 45.45 kg (100 lbs.). This amount of powder will last from two to three months when the unit is in operation approximately 20 hours a week.

The metal work cabinet which is available from the manufacturer of the unit is useful only when relatively small objects, such as archeological specimens, are cleaned in large quantities. As ethnographic objects vary greatly in size, we make a plastic bag large enough to accommodate each object with enough additional space to turn it easily as the work progresses. The hose connected to the dust collector, a unit separate from the airbrasive unit, is clamped to the edge of the bag and a strong air-flow vacuum draws off the abrasive and dirt residues.

The air may be supplied by an air compressor which maintains pressure at 5.6 kg/cm² (80 p.s.i.) in the abrasive cylinders. Glass beads are hygroscopic, so the air used must be absolutely dry. Since dry air is difficult to obtain when using a compressor, even with good filtration, a cylinder of carbon dioxide (or nitrogen) plus a pressure gauge is used instead. If cost is not a problem, the gas cylinder may be employed for all of the abrasives.

We use only two types of nozzle. Most commonly employed is the straight round-head nozzle with an orifice size of 0.66 mm (.026 inch). This opening will slowly increase with wear, but the change will not affect the work. For precise work around fine design lines, we use an obtuse-angle-head nozzle with an orifice of 0.46 mm (.018 inch).

Substances which are not removable with the airbrasive are gummy, greasy or rubbery deposits which will yield under the impact of the abrasive and will not abrade away. These may be removed with suitable solvents before the airbrasive cleaning is begun.

Materials which have been successfully cleaned in our laboratory are basketry, beadwork, bone, feathers, leather, metal, metallic embroidery, paper, pottery, shell, stone, textiles, and wood.

Basketry specimens are so varied that it is difficult to give any hard and fast rules to apply to all cases. Usually any basket in good condition will clean easily with dolomite. Fragile ones or those decorated with feathers, beads and shell are more safely cleaned with glass-bead powder, although a skilled operator may obtain the same results with dolomite. Greasy baskets will have to be dry cleaned with a solvent or washed and dried, if this can be done without damage, before applying the abrasive.

A great deal of beadwork in our collections occurs in conjunction with other materials, such as leather and cloth. Sometimes it occurs with metal or basketry. If it is merely dusty, dolomite used at normal 5.6 kg/cm² (80 p.s.i.) pressure will clean it rapidly without any damage to the beads; if extensive cleaning is necessary, it is better to use glass-bead powder which will not do any harm to the beads themselves, although it is wise to avoid exposed thread or sinew.

Bone is a delicate material, particularly in archeological objects which are often brittle and soft. It is best to remove dried mud or dirt with air alone and if this is successful, to use glass beads at a lower pressure. Where the surface of the bone is eroded and the cellular structure is exposed it is necessary to be extremely careful so that the cell walls do not crumble under the impact of the beads.

Feathers, excepting fluffy, downy types, can be dusted with dolomite, but it is safer to use glass beads at a lower pressure than 5.6 kg/cm^2 (80 p.s.i.). Always direct the abrasive flow from the quill toward the tips of the feathers to avoid separating the barbs.

Much of the leather in our collections is buckskin. From experience we have found that airbrasive cleaning with dolomite is the only method which thoroughly removes loose dirt and at the same time restores the original velvety texture of the surface. Skins which have been damaged by water, heat, or stains will not be completely rejuvenated; only the deposits which occurred after the damage was inflicted will be removed. Painted buckskin should be handled with care, as the adhesive quality of paints varies greatly. Some are not affected by the dolomite treatment; other paint is powdery and chalky and will blow off the surface quite easily. For cleaning close to the edges of painted areas, the obtuse-head nozzle is very useful. The pressure should be lowered until the cleaning can be done with just two or three millimeters distance between the tip of the nozzle and the leather.

Copper and brass may be cleaned with dolomite, but if the corrosion is merely a thin layer of tarnish, glass beads will suffice. If a higher gloss on the surface is desired, this can then be obtained by buffing with fine bronze wool or rouge.

The airjet has great value in cleaning rust from iron objects. Dolomite will easily remove thin or moderately heavy deposits of corrosion and is particularly successful in cleaning pitted areas which are difficult to treat chemically. Tool scratches are avoided when using dolomite to clean iron filigree, low relief carving and lacy decoration. The slight grooving of the surface caused by the abrasive is easily removed by rubbing with steel wool or 400 grit silicon paper. Some specimens, such as many weapons made by African smiths, were never given a highly polished surface, so the hand rubbing leaves an entirely natural appearance.

Very hard rust cannot be removed with dolomite; one of the grades of aluminum oxide is usually adequate, and if necessary, one of the silicon carbide powders. The latter is to be avoided unless it is used to remove only the major portion of very thick corrosion, the final portion being abraded off with aluminum oxide. Protracted use of the very hard abrasives causes severe wear of those parts of the unit which come in direct contact with the abrasive flow. If these powders are used frequently or for many consecutive hours a special unit especially equipped with tungsten carbide fittings should be used.

Metallic embroidery - silver, gold, or silver with a gold wash - must be cleaned with glass beads, which remove the tarnish quickly and leave a satin finish. This is a gentler method than the glass bristle brush, since no strain is applied to the threads by rubbing. The best results seem to be obtained when the pressure is lowered and the flow of beads is ample. When the silver is coated with a gold finish, care must be taken to remove only the tarnish, stopping the flow of beads as soon as the metallic sheen is visible; otherwise the gold will disappear as rapidly as the tarnish.

Only a few kinds of paper can be exposed to the airjet. Printed paper is easily damaged, but plain paper may often be dusted lightly with glass beads. Most important factors are lowered pressure, increased nozzle-surface distance, and a light touch by the operator. Repeated applications of beads over the same area should be avoided.

Shell and stone are usually washable, but when the surface is rough, glass beads and full pressure will clean dirt from all crevices and pits very easily. Glossy shell should be cleaned with glass beads only.

Since wood specimens may have many types of surface treatment, the application of either dolomite or glass beads must be modified for each particular case. Some painted surfaces could be damaged by the injudicious use of dolomite; another could be cleaned with perfect safety. Testing on an inconspicuous area and using the softest abrasive at the beginning is safest, as some wood is as soft as the paint on the surface. On the other

hand, dolomite removes old, hard unwanted varnish from carved objects, with no attendant scratches and gouges which would be left by scrapers and no residue from chemical paint removers.

Textile cleaning must obviously be restricted to those small pieces which are parts of larger specimens of leather or other materials. Doll's clothing which cannot be removed from the doll without destroying original sewing stitches, linings of leather bags, headdresses, belts, etc. are cases in point. Greasy cloth must first be dry cleaned with solvents. Among textile fibers which are definitely too fragile to withstand the airjet are loosely woven wools, old silks, sheer materials and laces. Heavy cotton can withstand an astonishing amount of scrubbing with dolomite, but a magnifying glass should be worn by the operator to keep close watch on the fabric surface.

It should be kept in mind that the cleaning of the materials mentioned above is only mechanical. Active rust is removed, but the causes of the rusting have not been corrected. Tarnished silver has become bright again, but the surface has not been protected against future darkening. Therefore when objects are cleaned by the airbrasive process any fundamental instability remains unchanged.





THE PROBLEMS OF TREATING ETHNOGRAPHICAL SPECIMENS WITH APPLIED SURFACE PAINT

(To be read in conjunction with illustrative decorated slides)

H. J. GOWERS

We are all conscious of the problems facing the restorer of European oil paintings, and are aware of the universally approved methods of dealing with them. There is, in the field of Ethnography, a parallel but much less appreciated problem, namely that of cleaning, treating and restoring objects of tribal origin which, however important ethnographically, have through the application of painted surfaces, an undeniable aesthetic value.

The conservation of these objects has been, in the past, all too frequently neglected, but must now be tackled as a priority. At one time in the not too distant past, when a conservator, usually untrained, found an object in this category, he would probably realize the complexity of its treatment, and would carefully conceal it in an obscure corner before moving to the next object.

In fact this apprehension often proved to be more helpful to modern conservation techniques than that of the intrepid operator who made every effort to solve his problem. His efforts were often restricted by a minimal knowledge of background information on his remedial materials and the art history of the objects he applied them to. Inevitably mistakes were made and much damage occurred, the reversal of which still complicates the work of applying modern corrective treatments.

Due to the exceptional work done in our Research Institutes and Training Centres, we have gone a long way to putting things to order, but in this field much requires to be done.

The object of this paper is to illustrate a variety of the problems which face the conservator of ethnographical objects on which a painted surface has been applied, and to show too some of the problems which the many and varied supporting materials cause, and the conditions governing their conservation and restoration. It is not to submit or discuss a series of practical curative treatments for reasons which I hope will be obvious from the slides I now propose to show....

Item 1

My first slide shows a Peruvian Kero, or painted wooden beaker dating back to the Inca period. With its varnished finish it is perhaps the closest we will

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get to European painting, it has reacted with time as we would expect European paintings to react. The whole surface shows considerable craquelure. Treatment, on similar lines to those used on cleaning oil paintings has been used to bring to light a rather colourful representation of agricultural scenes - a valuable contribution to the study of Peruvian agricultural methods.

Item 2

From Java originate some very fine painted objects. The Wayang puppets, probably more than 150 years old, were made of untanned but carefully prepared hide which was very finely perforated before being painted and embellished with gold leaf.

The water-soluble pigments were applied in strict rotation; they show signs of being treated with dammar varnish. The problems excluding those accredited to normal wear and tear, are that the skin inevitably contracts with dessication, and contraction brings about blistering of surface pigment which accelerates as the process progresses. There is a need for the skin to be dressed, but without strict control, the dressing will penetrate the underside of the blistered paint layer as well as the upper side of the skin from which it has become detached. Both will be impregnated by greasy material making reattachment of the blistered paint a precarious and complicated operation.

Item 3

Masks of wood, also from Java and of about the same age, were painted similarly to the puppets, and for similar reasons except that in this instance the cause of deterioration of the painted surfaces was contracting wood; the paint tends to flake, it also tends to become powdery. After 150 years considerable cleaning is necessary. There is a method of accomplishing the cleaning without inflicting further damage. Damage occurs when what might seem to be a normal cleaning method is applied to water soluble colours and excessive pressure or abraiding swabs are used.

What appears to be simple cleaning will quickly reveal a brighter undersurface - this surface is likely to be not the top paint layer, which is easily removed, but an underlayer.

Item 4

A painted buffalo hide robe from the plains of North America is an excellent example of its kind. Due to the rather woolly nature of its surface the hide needs both cleaning and dressing; either process could result in loss of the rather fine detail of the painting. Until the advent of airbrasive treatment,

dry cleaning was a possible method of dirt removal, but not a very successful one.

Item 5

A painted opossum skin from Australia (now treated) presented a rather different problem. It was found in a small tin, folded into about eight, and in a dessiccated condition. It had become brittle and distorted. The woolly hair remained on the epidermic layer of the skin while the adipose layer was painted with geometrical designs in red ochre. The problem with this object was to relax the skin so that the colour was not disturbed and at the same time to ensure that the character of the hair remain unaffected.

Item 6

Inspection of a roll of painted cloth from Ceylon, showed the paint had been applied over a white ground, but rolling and unrolling had weakened this and the surface paint layer was flaking off leaving a rather loose white powdery ground. In addition to this, the cloth itself had deteriorated and was splitting along the lines of both its warp and its weft. The whole painted roll was in need of consolidation, but primarily, the supporting cloth had to be strengthened so as to retain sufficient flexibility to remain in a rollable condition - an operation which could result in loss of a considerable amount of surface paint. If the treatment had been long delayed, quite possibly some sections of the support would have become detached or irreparable.

Item 7

Closely associated with woven cloth are the various types of barkcloth, manufactured by soaking and beating selected pieces of bark into sheets of cloth-like material. This bark cloth is found in many parts of the world and has a number of uses. It can be seen here as part of the constructional material of masks from Melanesia, and in that capacity, as a very unstable support for the painted decoration.

Item 8

Many wood sculptures are either undecorated or have a single overall surface enrichment, but the malanggan carvings from New Ireland provide some of the greatest problems in the field of the conservation of painted surfaces. The sculptures themselves, often of a high quality, are not usually highly finished and rely to a considerable extent on finely applied decorative designs for much of their effect. The earth pigments used were normally applied after mixing them with water to form a slurry - seldom, if ever, was any binding medium used - so that the colours which were applied directly onto untreated wood, would quickly dry out to leave only a powdery decoration which was free to be removed or damaged by touch. Over a period of years much of this paint has been lost, while the remainder has got submerged beneath layers of dust in our collections. It is the removal of this dust without the removal of the remaining powder colour which makes cleaning these objects singularly

problematical. Even more complicated are some of the masks from the same Islands. These are further decorated with a variety of other materials, most of them vegetable and hygroscopic, and all require cleaning. Incorrect cleaning methods could very easily be responsible for loss of facial colouration, or if not loss, noticeable damage due to undersurface staining.

Item 9

Rather similar, but less ornate, are the painted wooden boards from the Nicobar Islands. This hentakoi on which the rather thickly applied paint can be seen to be flaking claimed to keep away evil, but its claim was totally rejected by wood borers, and the powdery wood, which survives, must be treated with a consolidant. Many consolidants suitable for the proper consolidation of wood in this powdery condition are irreversible, or, if reversible, reversible only by a process which may seriously damage the decorated surface.

Item 10

The bark on which the Australian bark-paintings are supported is, in its natural state, of arched cross-section when removed from the tree. Although flattened before being painted it has a natural tendency to revert. The results of such movement of the support upon the paint layer are obvious, and the problem of conserving this paint and at the same time laying flat the support gives rise to many complications.

Item 11

The Congo mask shows a rather heavily painted surface. A certain amount of fatty matter is sometimes used in the preparation of the paint to act as binding material but this thickens the paint with the result that it forms flakes on drying. The high humidity of the Congo tends to preserve such painting, but a change to drier climates will cause loss of flakes, sometimes at an alarming rate.

Item 12

The next slide shows a ceremonial figure from New Britain. It is formed on a cane and stick foundation overlaid with vegetable fibre bindings built to the required shape. Covering the binding is a layer of fibrous pulp which forms the skin and acts as the support for the paint layer. The "skin" layer contracts in time, causing cracking and flaking until finally large sections of painted fibre get dislodged and the under surface vegetable fibre binding is free to uncoil and exert further pressures on the skin to accelerate breakdown.

Item 13

Finally a few examples of Bushman art. Rock paintings collected from South Africa were painted directly onto rock surfaces. Often one painting is superimposed upon a previous one. The colours are earth pigments, soot, etc., with little or no binding medium. It is presumably because of the impermanence of the colours that we have this superimposition of paintings and it follows that when the superimposed painting loses its intensity and merges into the original, the problem to the conservator becomes that much more involved.

These are just a few examples within a specialized field, which face the conservator of ethnographical objects in his laboratory. The objects, once replaceable, can no longer be treated so, and conservation is now an urgent need. But conservation techniques and materials are many and varied, the degree of their efficiency varies considerably too. It is therefore most important that methods and materials be subjected to research and the findings widely circulated, for there are few generally accepted methods or standards laid down for conservators of ethnographical material to follow. Then the best possible conservation work may become the norm wherever these problems exist. Permanent improvement should be the aim wherever possible.







Ethnographical collections present particular storage problems for two main reasons. The first concerns the great variations in size of the objects which may range from stone arrowheads to canoes 20' ^(ca. 6 m.) long, and the second the variety of materials from which the objects are made. Furthermore the artifacts produced by primitive peoples were seldom intended to stand upright upon a flat surface and are consequently less comfortable stored in standard shelved cupboards than, for instance, European silver and glass.

In the Royal Scottish Museum the major part of the ethnographical reserves, comprising Oceanic and African material with some North American Indian and Eskimo costume, are kept in a tunnel-like cellar 100 ft long and 20 ft wide with a low arched roof. Before the new storage system was installed last year this material was crammed into a miscellaneous series of cupboards all having different locks; wooden cupboards with fixed shelving, redundant glass display cabinets, and metal cases, which had been squeezed into the cellar at random as the growing collection became increasingly difficult to contain. Many objects that were too large or too awkwardly shaped to fit into the shelves lay on top of cupboards or on the floor of the cellar (a sight familiar to many curators). Because of the acute shortage of space it was necessary to store the objects almost entirely according to type i.e. all African pottery together, and not by geographical and tribal area, which gave visitors to the collection a great deal of work in finding the material of their particular area of specialization.

We wanted to achieve a storage system which would allow us as far as possible to combine geographical and typological methods of classification, so that Nigerian material, for example, would be kept together, subdivided by region, tribe, and finally type of object. This kind of arrangement requires space and so we tried to devise a system which would make the most efficient use of the cellar area, satisfy the basic requirements of any storage system by ensuring that the objects

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be both safe and accessible, and above all provide the maximum facilities for flexible expansion.

Open trays rather than boxes were selected as the basic storage unit. Trays make quick inspection an easier task so that handling of the objects themselves is reduced to a minimum. The system eventually agreed upon in conjunction with the Supplies Division of the Department of the Environment was designed around a plastic tray with built-in runners which was already commercially available in Britain, and is used mainly by bakers and confectioners.

73cm x 42.5cm x 7.6cm.

The tray measures $28\frac{3}{4}" \times 16\frac{3}{4}" \times 3"$ (inside), and is made of injection-moulded ABS (Acrylonitrile Butadiene Styrene). ABS is non-toxic, precluding any chemical effect on the objects, and being a one piece moulding, there are no crevices or joints to harbour dirt. The rigid plastic is very tough with a good strength/weight ratio. ^{2.37 kg.} Each tray weighs 5 lb $3\frac{1}{2}$ oz which is much lighter than a tray of equivalent size in wood or metal, and there is less risk of abrasion to the objects. Each tray has built-in runners on both the top and bottom edges which give a positive location for slide-stacking. We chose the model with a perforated mesh base but the tray is also available with a solid base.

The trays are used in double-doored locking cupboard units built of African mahogany. Each unit is ^{1m 42} 56" wide and ^{81cm} 32" deep and they come in two heights, ^{1m 83cm} 6 ft and ^{2m 08cm} 6 ft 10" to take into account the variation in height of the arched cellar roof. Each unit is subdivided vertically by two hardwood panels, and the plastic trays slide lengthwise on hardwood runners screwed to the sides and dividers at 6" intervals. Each unit can hold a maximum number of 54 trays, or trays may be removed at intervals and separated according to the size of the objects they contain. Owing to the modular design of the units the trays are completely interchangeable and may be transferred from one unit to another without disturbing the objects. The vertical dividing panels are secured by brass bolts to the unit so that one or both may be removed, and the space thus created can then be divided horizontally by

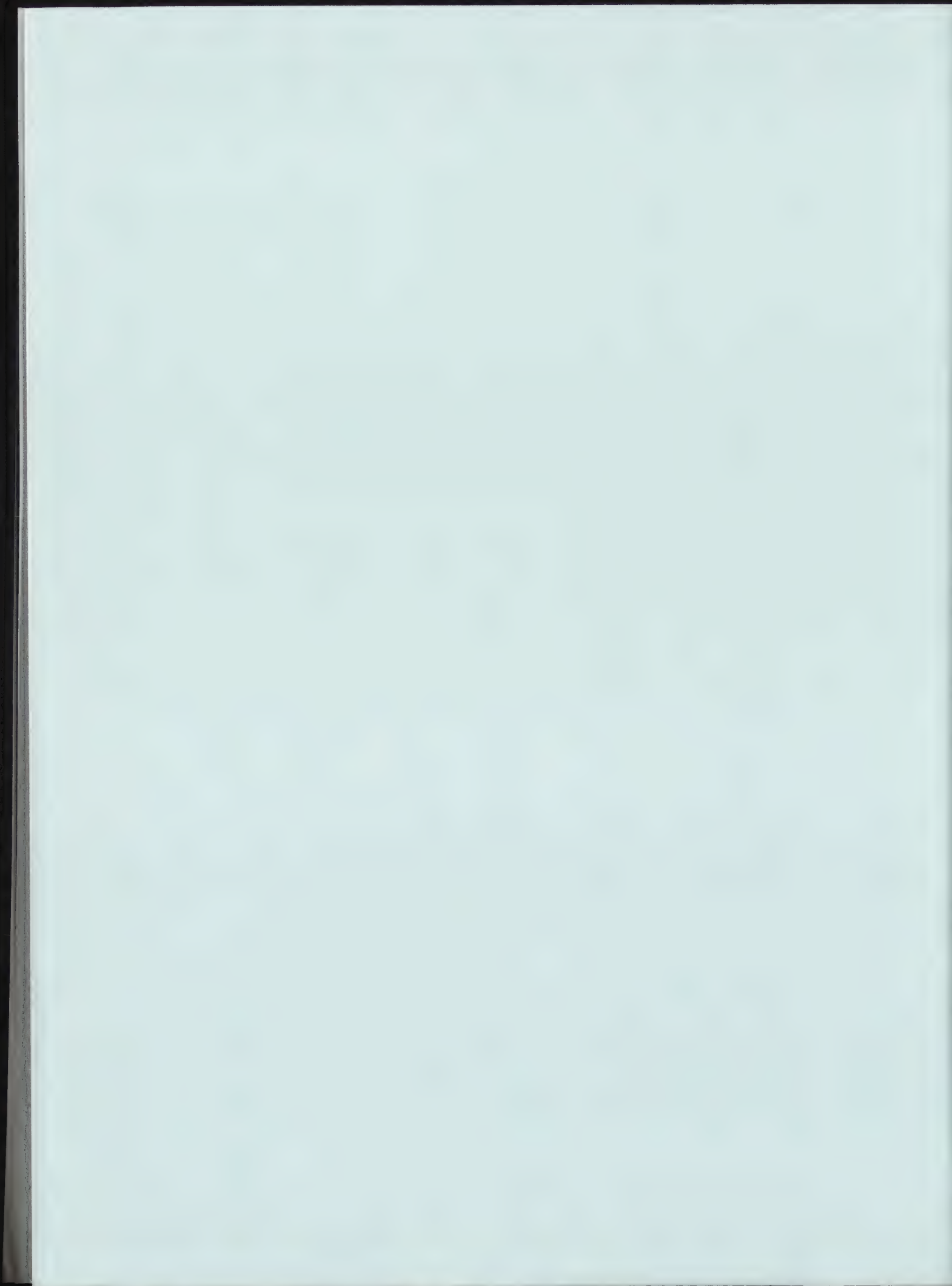
shelves which rest upon the hardwood runners screwed to the sides.

The units with the internal fittings provided: trays, vertical dividers and horizontal shelves, are very adaptable, and by employing different permutations it has been possible to store the collection in a far more satisfactory manner. We have not, however, been able to store the collection entirely upon a geographical/tribal basis. There are two classes of object in particular which it has been necessary to keep together, costume and weapons. These have required special solutions since the tray and shelf system could not satisfactorily accommodate material of this kind.

The problem of storing costume was solved by using three large bays in the cellar as locking wardrobes in which the garments hang from rails on padded hangers. The problem of the weapons was more difficult because of their variation in size and weight. Ideally we required a solution that would permit individual examination of each item and yet not be wasteful of space, and eventually we arrived at a system of vertical sliding wire-mesh frames. A similar method is frequently used by art galleries for storing paintings, and the British Museum has used static wire-mesh frames for ethnographical material. Our version incorporates the vertical frames within locking cupboard units. Each frame consists of a ~~square~~ mahogany framework ^{6'4" x 4'9"} covered with ^{5 cm} 2" expanded steel mesh, plastic-coated to prevent abrasion, to which the weapons are attached. Each frame slides out of the unit on an extending overhead metal track to permit individual inspection of the specimens. _{1m. 93 x 1m. 45}







Being a museum curator responsible for ethnological collections and also an ethnologist specialising in aboriginal technology and material culture, I am, naturally, deeply interested in the conservation of ethnological material. This interest is by no means a narrow one for it runs the whole gamut: from simple objects to ethnological photographs and sound tapes; from ensuring proper attitudes among museum personnel in the handling and storage of specimens to stimulating research projects devoted to the more complex problems of preservation; from determining priorities in research and treatment for museum collections to studying the particular problems, both technological and cultural, presented by open air museums and by ethnological material, such as totem poles, that needs to be preserved in situ.

However, my concern in this present paper is not the technological problems of conservation — these will be very ably discussed elsewhere in these meetings — but rather the position of the curator of ethnology with regard to collections and their conservation. An understanding of this is, I feel, important to any consideration of ethnology conservation for it is, after all, the curator who normally determines what objects should be acquired, loaned or exhibited and even in what manner they should be kept and to what level they should be restored. Indeed, in many museums throughout the world, the curator of ethnology must perforce be his own conservator.

Unlike the biological sciences, ornithology for example — where it is usually easy to differentiate exhibition and study material and where all important type specimens are carefully identified and protected, the cultural field is rarely so clearcut: in ethnology, there

are no typespecimens; objects are usually both scientific specimens and exhibits; identification is often casual and haphazard; the aesthetic appeal of an object is sometimes allowed to outweigh its scientific merit; acquisition policies are frequently ambivalent — seeking both soundly documented and authenticated ethnological specimens and also attractive exhibition-worthy objects with scant regard for such data.

For the museum ethnologist, however, the primary importance of an object must be its value as a source of information on the culture concerned. In terms of exhibitions the same holds good, for the object is but a vehicle that enables us to convey ideas regarding the ways of life of other peoples, including their technical skills and their aesthetic values.

Because of weak documentation and often doubtful attributions, a curator must often accept that a major part of the collections in his care needs very careful research to determine what is of real scientific value. The absence of a system of type specimens and rapid authentication plus the fact that these doubtful objects in a collection can be of considerable number make the situation no less difficult. Nevertheless, the curator must continue to conserve and protect them impartially until such time as they can be evaluated. With the rapid drying up of sources of ethnological material and with the growing realisation of the importance of cultural heritage, these objects achieve a new significance and the need to develop techniques for their handling and proper evaluation increases.

The conservator and the curator normally meet in the context of the museum. Rarely does the conservator have the opportunity of seeing the curator of ethnology under field conditions for any length of time, and his first sight of the resultant collection is usually when the objects are removed from their packing cases on arrival at the museum.

Yet the conditions under which a collection is made in the field affect very greatly the attitude of the ethnology curator towards museum objects. Seventeen years ago I made my first field collection — among Masarwa in what is now north-east Botswana. Since that occasion I have had numerous opportunities to observe — and often to be amused by — my own behaviour pattern and reactions to field conditions and to confirm these from my observations of colleagues both in Africa and in North America. Since the best collections, ethnologically speaking, are the product of fieldwork by a trained ethnologist, a consideration of such field conditions is useful.

— The sequence of events appears simple: the field ethnologist acquires an object from the local people, gathers the appropriate documentation, stores the object until his departure and then packs it carefully for the journey to his museum where it becomes a "museum specimen" to be treated with considerable care and preserved in its authentic condition. What may well have been a very mundane object in the village attains a new importance, almost a "sacred" state. The object is in fact frozen in time. This sequence is indeed simple.

But what in fact really does occur in the field? Although some curators do make specific collection trips or go to the field in large expeditionary groups, I would suggest that normally the museum ethnologist goes almost alone to a chosen field to learn as much as possible in a limited time about the local peoples and to document their culture — both social and material. Time devoted to the actual acquisition of objects is to a certain point gladly spent but work beyond that point or their subsequent day-to-day inspection and management quickly becomes an onerous chore. The acquisition of a particularly fine specimen kindles enthusiasm but the normal viewpoint is of specimens as a source of data not as aesthetic objects to be given full museum treatment. This

field attitude towards objects is understandable. Lacking skilled staff and increasingly conscious of his limited time and limited resources the fieldworker must concentrate on what he considers the most important topics and ^{on} gathering as much data as he can.

In all fairness, I should mention that, given the choice of a companion, I doubt that such an ethnologist would choose a conservator to relieve him of this particular burden. His priorities are normally such that he would prefer a linguist, a physical anthropologist, a film photographer or an audio-visual technician to augment his own field work.

- Something I myself have always found a little hard to accept is the sudden change from participant to observer status. In our own society the ethnologist is expected, as is any man, to conform, to be reasonably efficient in his work and activities. In the field, however, the ethnologist is essentially an observer and must refrain as far as possible from direct interference in the local society. If this is the case in social, ritual, economic and even technological activities it is no less so where a material object is involved. To intervene where carelessness, ignorance or mismanagement threatens damage to an object — a clay pot, the flights of an arrow, a reed mat, a canoe — could dislocate very quickly the rapport between the ethnologist and the community. And anyway why bother when there are so many examples of the object available in the village? The museum ethnologist cannot afford to impose rigid museum standards and attitudes in this new environment.

Even after an object is acquired and stored — in a tent or hut — it does not automatically acquire museum status. Besides continuing to be vulnerable to local climatic and insect damage, it is often dirty or damp and must on occasions be handled by villagers keen to learn

what interests the foreigner or to help identify a material, a motif or the personal history of the object itself. It would be an unusual ethnologist who refused to allow villagers to touch such objects of their own culture, for the giving of what could be viewed as gratuitous offence might well have serious repercussions. Again, to what end for replacements for any items damaged are usually readily available.

When it comes to packing and transport different problems present themselves. Choosing isolated communities as they so often do, ethnologists come to expect difficult access routes. Because of transport costs and other factors the import of sophisticated packing materials must be kept to a minimum so, when it comes to packing specimens for the return journey, local materials are often necessary. I myself have used — and most effectively too — thick padding of local grass tied round with *Hyphaene* palm leaf strip to protect clay pottery in journeys from the field; there are many other expedients. But bulky or very heavy items present particular problems that are not so easily solved and frequently they have to be transported unprotected.

The actual transport of a field collection — drawing on my own experiences -- can be exasperating. Keeping objects dry during a journey in a cranky dug-out canoe, or even later drying them out on the bank, is a problem in itself to say nothing of difficulties caused by rain or blazing sun. Clumsy carriers who fail to avoid low branches or who jar their loads when putting them down; packages that unaccountably come loose: all these are normal tribulations as too are the damage risks encountered in over-eager assistance in the loading of the collection onto a vehicle and the incessant jolting that results from long journeys over bad roads. There is too, for many museum collections, the final journey by rail, boat or plane when they are at the mercy of our modern systems of freight handling. Preparation for this may require repacking in substantial containers.

A point I would emphasize is that for the object the change in status from ordinary village artifact to hallowed museum specimen is one thing — a simple progression though, of course, physical adjustment to new climatic and storage conditions must take place after arrival. For the ethnologist responsible, however, the change is not that simple. On his return he must make the change back from passive observer to active participant in museum affairs and indeed for at least a few days he is disoriented and in process of readjustment to his museum surroundings. Even then some of the attitudes he has acquired in the field remain, particularly if he maintains an active field research-programme that entails regular expeditions. He indeed accepts that the objects he has collected are now museum specimens to be treated with care but I doubt that he is likely to achieve quite that degree of carefulness that distinguishes the conservator. He continues to regard them as scientific specimens, sources of data rather than solely exhibition objects though naturally he is happy for them to be exhibited. Furthermore, judging from my own earlier experiences, he retains a mental picture of the quantities of material still available in the field locality should replacements be required. That local conditions can rapidly change and sources of material dry up, often do not change appreciably this mental picture.

This perhaps cavalier attitude can carry over into the curator's relationship with other parts of the museum collections in his charge. This approach is not helped by pressures and other factors to which both he and the collections are subject. Ethnology collections suffer from their very quantity and variety. They tend to be inadequately housed, poorly managed and little appreciated. The considerable shift in emphasis in anthropology towards social, non-material studies during this century, has meant a sharp drop in interest in material culture, a

drop that is thrown into sharper relief by reason of the enthusiastic over-collection of massive quantities of objects during the nineteenth century.

The management of these large collections is something you are familiar with. I would mention, however, that since they are for the most part unpublished, they are often little known and, as a result, attract relatively little visiting research activity. The whole is a vicious circle: collections difficult of access with often dubious documentation; restrictive and poor service for those wishing to consult them; insufficient curatorial staffing to ensure publication; consonant lack of research interest and usage even by the staff themselves; resultant lack of justification for increased staff to manage the collections and to improve their conditions and documentation. Fortunately, we seem to be past the nadir of interest in material culture and, particularly with modern systems of communication and documentation, can look forward to some improvement in the situation.

With the creation of new independent states in many parts of the world during the past decade or so, there has been a considerable upsurge of awareness of a people's own cultural heritage. For ethnology this has meant a radical change in outlook. Not only must ethnologists today accept full ethical responsibility towards their field localities, but also the people themselves of these localities are undertaking their own cultural studies, building their own museum collections. Ethnology is indeed no longer the study of other cultures; for many it is the study of their own.

For the museums in these new states the problems are often heightened. A few have inherited good, organized collections; others have inherited collections comparable in size and condition (and accordingly problems) to those of museums in older established countries;

yet others have had to begin from nothing or with a mere handful of objects. The recruitment of trained museum ethnologists is never easy; for such new museums it is very difficult indeed. The establishment of sound procedures of documentation, care, storage and exhibition is often too great a problem for the staff and other resources available. The building of collections by means of fieldwork is similarly handicapped and, all too often, curators in these museums find themselves following the treacherous path European and American museums beat in the nineteenth century, of amassing specimens in far greater quantity than they can reasonably cope with properly. An alternative approach is the neglect of field collection and a very slow buildup in collections as a result.

For such museums there is an urgent need of basic training and manuals for documentation, collections management and conservation. When one looks at a continent like Africa, for so long a rich source of ethnological material, and notes just how few are the trained ethnologists in appropriate museum positions and how very, very few are the conservators, one can appreciate the seriousness and urgency of the problem.

Next week, here in Madrid, the Steering Committee of the ICOM International Committee for Museums of Ethnography will meet to discuss projects and activities for its 1972/74 programme. It will no doubt be touching on a number of the problems I have mentioned in this paper. One major group of problems will, of course, be those concerned with ethnology conservation in its widest aspects for, as we have seen from the recent reports of our corresponding members in some fifty ICOM countries, conservation is a subject that is of widespread concern and there is a strong interest in a major expansion of work in this field; an expansion not only in terms of greater efforts in finding

solutions to technical problems of preservation and restoration, but also in setting standards for the care of collections and of objects on exhibition and also in salvaging as yet uncollected material from fast-changing cultures.

Naturally, the International Ethnography Committee will be seeking the advice and assistance of its sister Committee on Conservation. In closing, however, I would like to take this opportunity provided by this specialised meeting of inviting your comments on what projects you consider most urgently need to be undertaken in ethnology conservation and of asking those who might be interested in working with the Ethnography Committee on conservation (or other projects) to contact me sometime this week; I would assure them that their help would be most warmly welcomed.

October 1972

Barrie Reynolds
National Museum of Man
National Museums of Canada







CONCERNING CONSERVATION OF ETHNOGRAPHIC
HERITAGE

Speaking about the ethnographic heritage, one must bear in mind the rich historic material accumulated in ethnographic museums. These material monuments of history and culture of the peoples sometimes date back to the 18th century. But for the most part the ethnographic museums have collections of material monuments relating to the period of the 19th and the first half of the 20th centuries.

Most of the ethnographic museums started collecting monuments beginning with the 19th century, and their collections very often have a century-old history.

It should be noted here that most of the monuments kept in the museums had been of practical use before becoming museum exhibits which fact could not but make its imprint on their preservation. While being kept in the museum, these monuments have been under the influence of such factors as temperature fluctuations, humidity, light and purity of the air as well as some biological factors.

The time is of no small influence here for the things are aging as the time passes. That is why, the problem of conservation of historic and cultural monuments is acquiring ever vital significance from year to year. This problem has become the concern of museum workers irrespective of their nature: be they historic, ethnographic or other kinds of museums.

To preserve for many centuries to come the heritage of the past, to keep for the future generations the treasures of mankind's culture is both the honorary duty and an obligation of museum workers, museum curators in the first place.

That is why, museum curators should be people having a higher education, well acquainted with the tasks of conservation and knowing the processes taking place with the material of the monument. The curators should take into account interrelations between the materials and the environment. It is the duty of museum workers to take the necessary precautions, in due time and without mistakes, for preventing and stopping the process of destruction of monuments.

In the light of the above mentioned, the curator should have extensive knowledge about restoration. Among the museum curators must be chemists, physicists and ethnologists so that the curator's work correspond to the high level of contemporary science and to the demands of the time.

It is very important to relieve information on new trends and practices in museums of different countries. Unfortunately, the materials of meetings and conferences on the problems of conservation, far from being accessible, are often kept unknown for the curators working in the museums of other countries.

It is high time to establish, within the ICOM framework, a magazine devoted to the trends in the theory and practice of conservation of museum collections and their restoration.

Museum experience has shown that conservation embraces not only all the special measures aimed at preserving museum monuments. The term "conservation" has a broad sense when used in our press: it means preservation and conservation, i.e., creation of such

conditions for the ^{monument} ~~monument~~ which, taking into account its physical, chemical and technological properties, open possibilities for its conservation for many years to come. All the questions pertaining to conservation of ethnographic ^{by} heritage are to be settled on the highest scientific level. Research should be based on the means and methods of modern physics, chemistry and biology. Hence the acuteness of the question of creating an information centre to generalize and, in a certain sense, coordinate and lead the activity of specialists in charge of the historic heritage conservation.

Many of the monuments and collections kept in the museums and dating back to the mid-19th century, could have marked their "centenary". In the majority of cases they need to have been rendered "first-aide" restoration.

As long as restoration is aimed at preserving a monument in its original form with all the distinguishing features and qualities, it should be effected intricately. "Restoration is full or partial rehabilitation of the damaged museum monument and its fixing... In order to avoid irreparable damages, restoration work should be made only by specialists in restoration."¹

It should be mentioned that the problem of finding good restoration workers for the museums is of as much importance as

Foundations of Soviet Museology. Moscow, 1955. P.p. 152-153.

the question of having experienced curators. In choosing the museum staff we pay adequate attention to both questions.

Many of the museums have dozens and sometimes even thousands of exhibits. Thus, the State ~~Ethnographic~~ Ethnographic Museum of the Peoples of the USSR in Leningrad has a quarter of a million exhibits of material and spiritual culture of the 134 peoples inhabiting the Soviet Union today. In December this year, we shall mark the 50th anniversary of the formation of our multinational state. Some of the exhibits need to be restored th every year.

~~The process of aging is irreversible. That is why one per cent of the total number of exhibits is quite a considerable ammount of monuments -- 25 thousand exhibits --~~

The process of aging is irreversible. Every year the number of monuments under restoration reaches a considerable quantity -- 25 thousand exhibits, though they account only for one per cent of the total number.

The problem of keeping the collections open to visitors in the museum halls is of special importance in the conservation problem.

The exhibits displayed in the museum halls for visitors constitute, as a rule, about ten per cent of all the material the museum has. Usually, from 85 to 93 per cent of the exhibits are kept at depositories. The exhibits in the halls are kept in special cases, windows, stands and podiums. In such cases the exhibits are in danger of being damaged more quickly than in depositories.

Much depends on the form of exhibiting the monuments, the system of their fastening, the light, biological factors, the influence of condensed air or its absence. We do not rule out the possibility of monuments being stolen.

The problem becomes still more complicated for very often the cases and windows are not hermetically closed. The above said bears to the difficulties of museum conservation.

It can be noted once again that many museum monuments are made of heterogeneous materials: metal and fabric, iron and leather, etc., which makes the complicated and diverse process of conservation still more complex and many-sided.

It is desirable that special houses be built for ethnographic museums having its own "museum" climate and new type of equipment. This will contribute in great measure to the future conservation of museums and their monuments. However, modern museums, as they are today, very often have no up-to-date equipment not only for the expositions but even for the depositories.

It is time the problem of designing special museum furniture which is inexpensive and easy in exploitation, be solved. It should be appropriate to declare contests for designing such furniture, with the broad discussion of the designs.

Undoubtedly, some degree of specialisation of exposition equipment would facilitate more convenient and fruitful systematic exchanges between museums of different countries.

With this aim in view, special structure for transportation of exhibitions should be worked out to meet the requirements of conservation during transportation. Such unified and mutually acceptable equipment could be recommended for all the museums sending their exhibitions to other countries.

Special attention should be attached to personal contacts among museum workers of different countries. It is practical work in each other's museums in the first place.

The experience accumulated by the State Ethnographic Museum of the Peoples of The USSR confirmed the fruitfulness of such contacts. For many years now, the museum works ^{or} have ^{been} going to work in museums of Hungary, Poland and Czechoslovakia. In their turn, museum workers from these countries come to the State Ethnographic Museum of the USSR.

It should be desirable to hold regular symposiums or even congresses (every three or four years) which would discuss questions of conservation of ethnographic heritage and a number of other issues closely connected with museum conservation.

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working group : Documentation

H. Barker



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ICOM COMMITTEE FOR CONSERVATION -DOCUMENTATION GROUP

Report on activities outside the U.S.S.R.

Harold Barker

23/4

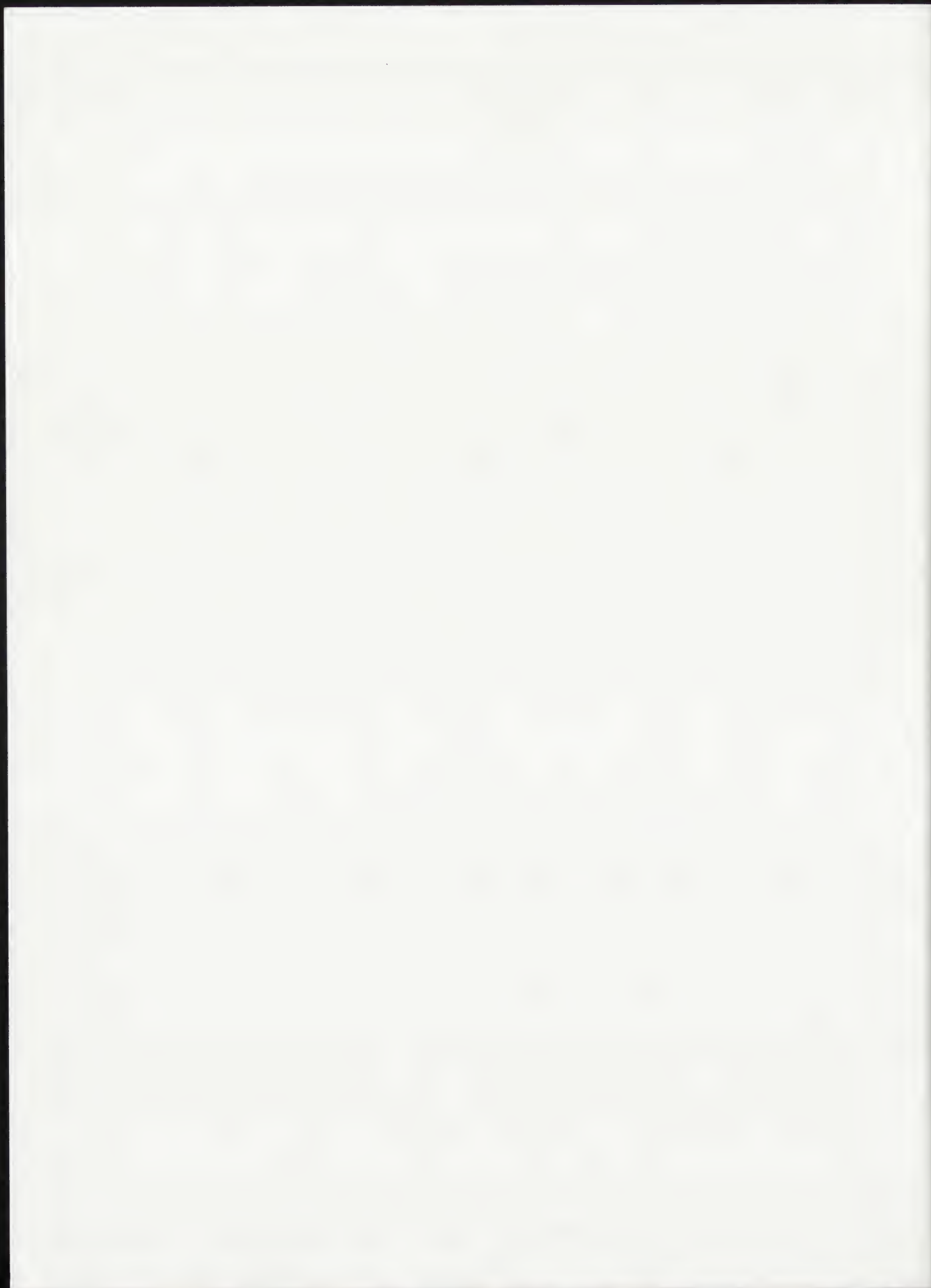
During the period since the last meeting of the Committee in Amsterdam, work on documentation has been concerned mainly with an investigation of the various systems of documentation and information retrieval. There seems little doubt that there is a general trend, at least in the larger museum laboratories, towards the use of the so-called "feature card" (optical coincidence card) systems for indexing information.

Kuhn and Zocher (Studies in Conservation 15, 1970, 102-121) have described the use and advantages of such a system in the scientific study of paintings, and Oddy and Barker (Studies in Conservation, 46, 1971, 89-94) have described a similar system for the general museum laboratory. The chief advantages of feature card systems lie in their cheapness and their flexibility which sets no limit to the number and choice of features to be indexed. Thus they are equally suitable for specialist and more general applications. Their main weakness lies in the practical limitation set by the number of positions on the card. The 10000 position card would seem to be the largest that can be conveniently used in practice although cards with more positions are available. However, for larger collections of objects, indexes based on the electronic computer are likely to provide a more satisfactory solution, and as the work of conservation laboratories grows and their files proliferate, and as computers come into common use, it will become increasingly necessary to consider the possibility of using these electronic aids. The British Museum Research Laboratory plans to develop such a system within the next few years, and experience gained in this project will of course be made available to the Group.

Guidance on the choice of features to be included in a feature card system can be obtained by reference to the two papers quoted above, although it must be emphasised that the flexibility of the system allows complete freedom of choice without limit to the total number of features which can be included in the index. This unlimited freedom of choice could, in the absence of guidance however, lead to important features being overlooked, and it is suggested that a possible future task of the Documentation Group could be to establish and secure International agreement on minimum standards for the information content of records so that information relating to the scientific examination and conservation and safety of cultural property is not lost or rendered inaccessible because of bad record keeping and indexing.

2001/300

Harold Barker







ICOM Committee for conservation
Madrid 1972

Working-group "Documentation"

KINDS OF DOCUMENTATIONS OF CONSERVATION APPLIED
IN VARIOUS CENTERS

by
Bohdan L. Marconi

Conservation laboratories all over the world keep descriptive, photographic and drawing documentation containing the description of every object as well as the state of its preservation, results of laboratory research and the course of treatment. The sequence of the description and the arrangement of the photographic documentation is the same. Remarkable differences exist though in more or less detailed descriptions and the amount of photographs which should depict, at least within a minimum scope, the object before the conservation, in the course of treatment and after the conservation.

The conservation cards with the titles of particular positions differ considerably. Some of them contain a limited amount of the summarized positions, the conservator having to make a more detailed description.

Let me give an example of my own conservation card-envelope introduced about 1933 at the Warsaw National Museum, where the position "research" is divided into: 1/ microscopic, 2/ ultraviolet, 3/ X-rays.

Of course - item 1/ concerns both microscopic and microchemical examination; item 2/ - U.V. fluorescence and U.V. reflected from the surface of the treated object. Item 3/ relates to any kind of research connected with the application of X-rays such as static, layer-rotation, stereoradiography, autoelectronography, gammagraphy.

(envelope)
At the time of introducing the card-index, no I.R. photography was applied - hence this position is missing.

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The size of the envelope 15,5 x 20 cm permitted to store in it many photographs and additional descriptions. If the surface of the envelope in the position of "treatment" was too small to report the conducted treatment, it could be supplemented on the back of the envelope in the position of "comments".

As photographs 13 x 18 cm were generally used, the size of the envelope was sufficient.

The envelopes being too small, the roentgenograms were attached in photographic reprints of 13 x 18 cm drawn from 9 x 12 cm negatives or 24 x 36 mm taken from negatoscope. Such reprints were applied in many cases in reproductions illustrating articles.

Supplementing the card-index (envelopes) numbered successively every calendar year (eg.30/1938) card index files were arranged according to authors, schools, numbers of Museum inventory and owners in case of deposit or paintings sent in for exhibitions. If a painting had to be submitted for repeated conservation - as it often happened after 1945 - it received the new envelope with the number of the previous conservation and on its previous envelope the new number was given. Card indexes were also supplemented.

I think this method of documentation, a good one in principle, proved successful. This method has also been applied since 1945 in the State Studios for Conservation of Paintings in Chief Board of Directors of Museum and Protection of Monuments and since April 1951 in the State Laboratories for Conservation of Monuments (P.K.Z.) which were formed by reorganization of State Studios.

As of now however, I consider the size of envelopes too small. Their original size was adapted to easel paintings from Museum collections.

Numerous conservations of murals sometimes require bigger size of photography (18 x 24 cm).

Enlarging the size of envelopes to 33 x 43 cm would enable keeping photographic documentation as well as roentgenograms (usually 30 x 40 cm) kept so far in separate envelopes with successive numbers enlisted into a special inventory (book).

Diaries kept systematically during treatment, containing notes of observations, difficulties or showing details sometimes hard or even impossible to detect during preliminary and laboratory research - should be attached to these envelopes.

After several years State Laboratories for Conservation of Monuments (P.K.Z. - Pracownia Konserwacji Zabytków) discontinued the use of envelopes, having changed documentation into schemes of numerous, detailed positions - keeping of course the sequence of research and conservation work.

The reports are typed on a paper without titles of individual positions. They are set in a form of arranged ^Pcompendium from the work diary taking into account the data of the methods involved, materials applied, their composition and concentration, tests performed and reason for possible alterations of conservation treatment etc. It is also ~~change~~ required to give the means of assemblage or exposition if this has been changed after conservation. (Instruction of P.K.Z.) Documentation of conservation along with the results of scientific laboratory research as well as research from historical point of view and photographs is stiff-cover bound to make a volume of no more than 60 photographs stuck on cardboard.

In 1970 P.K.Z. worked out a detailed instruction for the Laboratories of Conservation of Works of Art. It contains schemes and instruction (66 pages) how to prepare reports suitable for any kind of objects: murals,

easel paintings, polychrom sculpture, sculpture, graphic arts and old books, textiles, metal objects, stained glass and old furniture.

The instruction gives in detail almost all expectable positions concerning scientific and technical research and conservation treatment.

A great part of the objects does not require so many research and execution methods.

Only methods applied are described here. In such cases, should a scheme containing many position be not completed - the often many positions without comment would still be satisfactory.

In the instruction 66 pages deal only with documentation of conservation, the remaining 103 pages contain patterns, instructions and schemes of administrative type resulting from the organization of PK.Z. which is a state-owned establishment.

Before 1939 some articles appeared on the subject of schemes used in documentation of conservation.

At the annual meeting of the American Association of Museums at Toronto in 1939, discussed was a plan of a scheme-card with the titles of individual positions (four pages folded, photographs inside) - prepared by a specially called Committee dealing exclusively with the problem of description of paintings, structure and state of their preservation. George L. Stout^{1/} in his article dealing with this problem considered difficulties of filling in the prepared form as well as shorter of larger form.

In 1939 G. L. Stout^{2/} reverts to the subject suggesting a reduced form^d of simplified card, saying that in usual practice we often come across paintings which do not present complex problems but often require minor treatment. In such cases the simplified card is more convenient.

3/
In 1941 an article by Helmut Ruhemann appeared "A Tentative Scheme for Analysis of Painting Technique" containing technological research as well as short discussion ~~on~~ the course of conservation.

This scheme could be applied in the case of paintings with specially interesting and complex structures. The examination of this structure would introduce valuable data to the history of painting techniques. It seems to me that in regular conservation work in museums - paintings of such type, a very complex structure and exceptional kinds of damages seldom get to conservation studios.

4/
My opinion is confirmed by George L. Stout who emphasizes that most paintings which get to the studios require comparatively small corrections such as scratching of varnish, surface cleaning, securing paint and ground flaking on a little piece of surface and filling and inpainting minor impairments. He states that for this kind of treatment (naturally preceded in every case by laboratory research - my note) such complex schemes are inadequate.

H. Ruhemann suggests later research and execution documentation
5/
remarkably simplified.

The big size envelopes containing roentgenograms are used in Tate & Gallery in London in Conservation Laboratory directed by Prof. Stefan Slabczynski. In Kunstmuseum, Dusseldorf, Dr. H. Althöfer applies cards "Restaurierprotokoll" of 29,5 x 42 cm with the titles of very few positions.

Nowadays the tendency to simplify the prints of documentation of conservation is being observed. The obvious sign of this tendency is the guideline given to the International Committee for Conservation ICOM issued

during the General Meeting of this Committee in Amsterdam in 1969 for preparing the simplified scheme by a special working group of which I am a member, with the coordinators: H. Barker of Research Laboratory, British Museum and U. I. Grenberg of Central ~~Laboratory~~^{e/} Laboratory for Conservation and Restoration of Museum Treasures in Moscow.

The program of the working group contains: 1/ working out the typical documentation, 2/ working out and suggesting to use simplified methods, economically possible to introduce both in small and in bigger museums and galleries, 3/ examining and advising methods enabling to introduce such cards into national and international systems.

We do not have to justify the necessity of keeping exact research documentation as well as documentation of conservation. Apart from the data concerning technical structure of the work, state of its preservation, establishment of the previous "renewals", their kind and technique of their making, authenticity, history based upon inscriptions and numbers, it is possible to get valuable information about painting technique for the history of conservation and history of the work.

Such documentation may help the historian of art in his attribution work and dating, while the obligatory photograph~~s~~ taken after technical conservation treatment but prior to inpainting gives the real picture of the actual state that the painting preserved to our times.

The important problem is the possibility to compare the state of a work of art many years after performed conservation - with the documentation. If the documentation is kept accurately, scrupulously and contains not only description of the performed treatment but also enumerates all

materials involved and the means of applying those materials, such control gives valuable critical hints confirming the proper course of conservation or inducing to change the means and methods used.

My own private notes of conservation kept since 1933, unfortunately only partly preserved, are priceless material for me. Detailed descriptions of each painting, state of its preservation, previous restoration, results of research, as well as the course of treatment with detailed materials and methods involved - permitted to confront the state of preservation after several years with documentation and photographs.

As I have mentioned before, the notes which were partly preserved, partly destroyed by fire in 1944 permitted to supplement the publication by Prof. dr. Władysław Tomkiewicz "The Catalogue of Paintings removed from Poland by Hitler Authorities in the years 1939 - 1945", Vol. I 1949, Foreign Paintings, with 34 positions and Vol. II "Polish Painting" 1951 with 26 positions. Those 60 positions are a small part of the works I have treated. Unfortunately those works where the photographic documentation was lost - were eliminated from publication.

I cannot disregard the advantage of the accurate detailed documentation for the executor - restorer.

It is sometimes claimed that in the course of conservation a painting is overcleaned. As we know, well preserved paintings occur very seldom. Most of old-time paintings were submitted to cleaning using drastic methods and intensive solvents already in XVIII and XIX centuries. Such overcleanings were often masked with colored varnish and repainting. The removal of this kind of varnish exposed the bad state of preservation of the original surface of the painting. Even now a little group of opponents against removal of deforming varnishes - supposes that "Madonna on the Rocks" by Leonardo

da Vinci in London National Gallery was overcleaned during the removal of yellowed varnish in 1948. Documentation of Conservation permits to establish that this serious charge is unjust.

I know from my own experience that the honor of a conservator can be defended only by means of exact descriptive and mainly photographic documentation.

The problems considered above concerning documentation - deal with works of art - paintings. Such works create most complex problems on account of the complexity of structure (support, ground, layer or layers of paint, gildings and varnish.)

For ancient metal, archeological, paper or parchment objects, as well as ethnographical objects, cards or envelopes with different printed positions for each kind of object should be prepared.

Ending, I wish to state that the value of documentation of conservation is not dependent upon full or simple scheme, the amount of positions printed for the conservator to complete.

The sequence of positions is determined by the very procedure of conservation: description, materials, sizes, origin, state of preservation, structure, changes, corrections, laboratory research, treatment, comments and instructions for preservation.

The value of documentation depends upon the exactness and detailed description of both preliminary and laboratory research and on strict but concise description of the course of treatment and proper amount and quality of photographs.

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I C O M

COMMITTEE FOR CONSERVATION

Madrid, october 1972

The Portal of the Monasterio of Santa María, Ripoll:
Latest performances within the Programm for its Con-
servation

José María Cabrera Garrido.

MADRID

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The Portada of Ripoll: Latest performances within the Programm for its Conservation. (1)

The treatment studied and proposed for the preservation of the facade of Ripoll was published in the Bulletin Nº 5 of the "Informes y Trabajos del Instituto de Conservación y Restauración, Madrid (2). Seven points were considered essential, which were specified with the help of a scheme and the first, and most urging, among them was applied on november 1964, consisting in the fixation, cleaning and consolidation of the carved surface, which was in an advanced stage of arenization (3). The remaining six factors to be corrected, as previewed in the above mentioned integral programm (see fig. 2), have been performed along the period of time comprised between July 1971 and May 1972; the itemization thereof being the subject of this communication.

(1) Under the Patronage of the "Juan March" Foundation.

(2) This paper has also been published in "Conseil International des Monuments et des Sites (ICOMOS)", MONUMENTUM, vol II (1967) p. 73; in the Simposio sobre la alteración de los materiales petreos en los Monumentos" ICCR - CSIC, Madrid (1965) and in "Conferences on the weathering of stones, Colloques sur..." Brussels (1966-1967) p. 127.

(3) The sandstone was impregnated with a solution of a polymetacrylic ester (Bedacryl 122 X, by I.C.I., London) highly diluted with xilene (approximately 5%), which enabled to sufficiently fix the stone surface as well as to clean out of it all salts and soil accumulated therein without affecting the underlaying stone material very much disgregated in a depth of some 2 cmts.; afterwards the same solution was applied several times (ma-

For a better understanding of the exposition, we will base ourselves upon the numerical order established in fig.2 attached. We are shortening the verbal process to the strictly necessary minimum for the correct understanding of the attached graphic documents.

1st.- Elimination of the dust layer piled up during the last seven years; we have used a powerful electric vacuum machine, with the help of the mechanical action offered by smooth hair brushes.

2nd.- Filtration from the facade's roof were leading upon the facade's back wall strengthening. We have raised off the roof-tiles in order to cover the wooden frame with glass fiber and polyester resin, placing again the roof-tiles to assure an efficient protection for the resin (see figure).

3rd.- The canting shown by the facade in the right upper end, separated from the wall some 15 cms. and reunited with fast setting concrete, plus the fact that all the upper part of the facade has 40 cms. of debris filling material accumulated upon the back wall, origi-

king the solvent evaporation speed as low as possible, creating to this end a xylene steam saturated atmosphere, isolated from the outside with a huge polyethylene bag) until we obtained, with the adequate penetration, a hardness degree enough to assure the material stability of the reliefs.

nally built with rolling stones, requires holding the Facade, making it stronger by attaching it with metallic staples to the temple's wall. We have used galvanized iron staples, placed as shown in figure . As soon as the structural stability was assured, we have eliminated the debris filling, uncovering the rolling stones of the original back wall, that have a great porosity and assure a good ventilation of the Facade extrados. We have also eliminated the Gypsum with which some of the soffits close to the Pantocrator had been fixed. When the debris was taken off, the Lombard arcuations with mortar plaster, made with lime and smoothed with trowel and remainder of mural painting were alighted (see Fig.).

4th.- Eliminate the Temple wall to which the Facade leaned. This involved structural problems difficult to solve. According with the Monastery's Arquitect Curator Mr. Alejandro Ferrant, it was deemed convenient to make some trial-pits in the Church wall, in order to be able and study the Facade back wall (see fig.). Upon the side wall of trial-pits A and B it may be noted that the Church wall is made with the country's quarry stone surrounded by good quality lime mortar; the Facade extrados, exploring at the level of plant and choir, is made with river rollig stones, large sized and attached with scarce mortar low of lime. Behind the Facade, the Church wall shows a parament with traces of plaster made with lime mortar and smoothed out with trowel, which is more abundant in the upper areas. The Facade of sandstone, is

composed of soffits with some 25 cm. of thickness and of imposts penetrating up to 60 cm. of depth .No traces of any attaching mortar have been found, but on the outer side attachment is made at times with fast setting concrete (4). In the extrados, the sandstone shows frequent exfoliations and a slight arenization in its surface. The complex is practically dry.

Therefore, the ventilation of the Facade extrados has been restored, assured by the enormous porosity of the extrados with large size rolling stones; on the other hand, the A and B exploration trial-pits have been converted into ventilation funnels (5) , closing the openings in the inner parament of the Church wall with a wall thickness smaller than the original one, and placing metallic racks in the conduit upper and lower end; the lower rack, placed inside the Temple, has been fitted with an adjustable lid, allowing to regulate the air flow.

(4) All repairs made with ready setting concrete we found in the Facade and around it, seem to belong to the restoration made in the Monastery by the Architect Elias Røgent (1886 - 1893); old photographs, such as that in Fig. , show that around 1890 the Facade did not have the elements it now has (see underline in Fig.).

(5) The forced ventilation of the funnels made, since acting in a diffuse way through the thickness of the back wall, larger than 0,6 m., cannot produce localized effects upon the Facade.

5th.- In order to study the eventual supply of moisture and salts from the floor, we have previewed to check the Facade basement and, if necessary, to isolate it from the basement by cutting it and inserting a continuous waterproof film. A trench was excavated all along the basement, according with what is show in the plan of Figure. The Facade support is made with sandstone blocks similar to those of the Facade, some of which are materials from other constructions (6).

The Facade is practically isolated from the basement by the sandstone plinth with ready setting concrete, identical to the present door-sill, which we know was placed around 1890. On the other hand, the moisture contents in the basement sandstone is very low and we feel, therefore, it does not justify the pretended need to cut the Facade and isolated it. What we have done is to empty the trench made, covering it with the slabs pavement supported by pillars in order that it may act as a ventilation duct though one of the exits with metallic rack, situated some 25 cm. above the outer parament of the Church wall, on the left hand and rigth hand sides of the Facade.

The excavation around the basement has alighted no type of loose archeological materials, but has enabled us to observe the following data: First of all, the Facade surmounts the slabs in a threshold, prior to that, therefore, having the marks corresponding to the attachment

and closing system for a door that did not exist anymore when the Facade was placed, since the door's swivel axles are very inside of the Facade cornice; under this old threshold, the Temple wall follows on with a regular parament (see section b - b') down to an explored depth of 1,5 mts. in which it is noted a protuberation in the wall and, on the floor, a lime and sand mortar layer (see section d - d' -. Both on the Facade right and left hand sides, we have ascertained the existence of some wells(7), 1,7 m. and 3,8 m. deep, respectively, in which it is noted that the wall parament is of perfectly plumbed quarry stone that cannot be considered as basement(8).

(6) The basement stones, quoted at 54 and 21 cm. underneath the floor level (see location on plan y=6, x=8 . y=6, x=15) are two half columns of the same size.

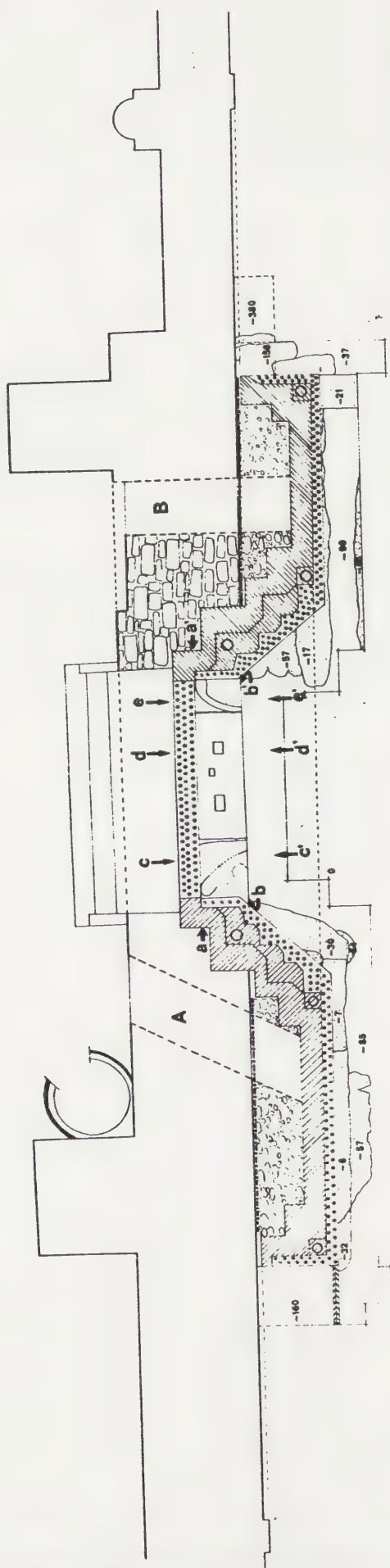
(7) These wells may be considered as ossariums, since there are several boxes with a large amount of human bones; they are covered with a small vault of hollow bricks, which assures us that they have been covered after 1938, since prior to this material did not exist in Spain.

(8) These two areas are under the Monastery towers; although it does not seem that they have been constructed as basement, they may have been used, filling them up, to this purpose, in view of the higher pressure it has to stand under the towers.









6th.- Leaning on the portico arcade a glass protection has been installed to assure an efficient sheltering of the Facade against the severe climatic condition in Winter. The project, made by the Architect Mr. Alejandro Ferrant, has been performed by the Barcelona constructor Calixto Cruz under the supervision of the works Manager Mr. José María Valero Yago. We are attaching the general layout (Figure), and will underline the assembly system, with pillar axis in the Portico inner part, addressing the mechanical effort towards the parament and not upon the pillars. The climatic conditioning of the so closed Portico firms, under the Patronage of the "Junta de Obras del Monasterio", the project having been approved by the Architect.

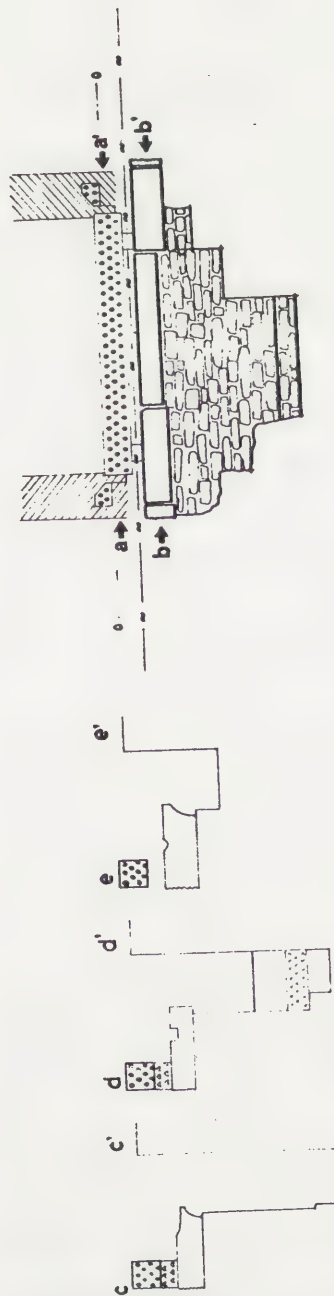
7th.- The channel feeding the factory lying by the Monastery has been suppressed after demolishing the factory, all of which lies within a larger programmes out from our concern.

escala en metros



A y B - catas practicadas en el muro de la Iglesia, explorando el trasdoso de la Portada a niveles de planta y coro.

-  piedra de cantera del país con mortero de cal.
-  paramento con restos de revoco y pin-tura mural.
-  cantos rodados con mortero de cal.
-  portada en piedra arenisca (plafones= 25cm, imposts=60cm.) sin mortero de recibo.
-  zócalo y umbral (de hacia 1890).
-  basamento portada en piedra arenisca.
-  argamasa cal y arena.
-  argamasa con "cemento rápido".



PROGRAMA PARA LA CONSERVACION DE LA
"PORTADA DE RIPOLL"

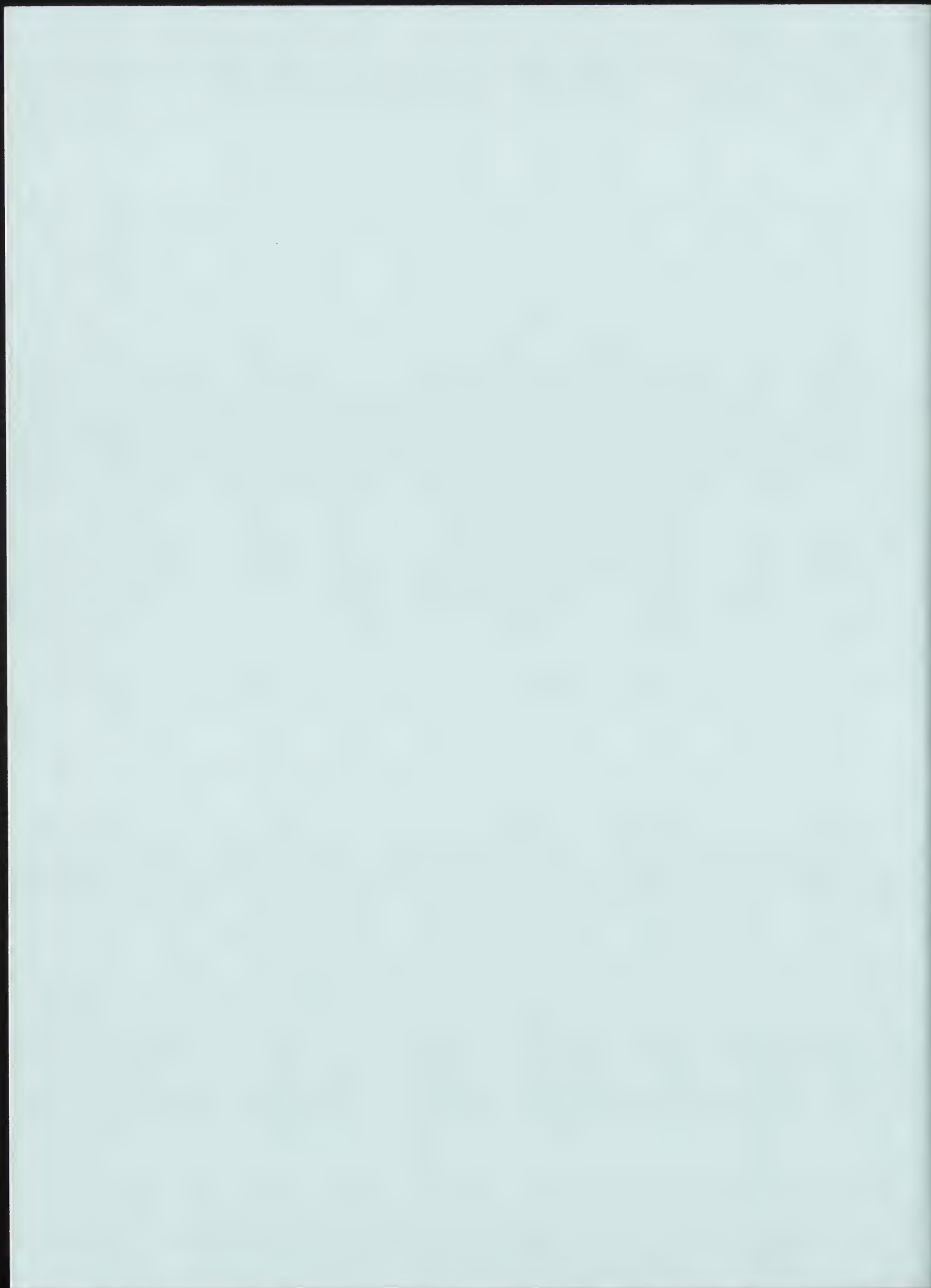
I.C.R.

mayo de 1972

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THE PRESERVATION OF ARCHAEOLOGICAL WATER-LOGGED AND CARVED
CHARRED WOOD IN THE STATE HERMITAGE MUSEUM

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THE INTERNATIONAL COUNCIL OF MUSEUMS CONSEIL INTERNATIONAL DES MUSEES
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The preservation of archaeological water-logged and
carved charred wood in the State Hermitage Museum

A Water-logged archaeological wood

From 1954 to 1971 a large number of wooden objects of X-XV centuries passed through the hands of the Hermitage conservators: finds excavated in Pskov, Staraya Ladoga, Toropetz and Novgorod as well as wooden objects from a neolithic stand discovered in the village Usvyaty of Nevel district Pskov region. Both the medieval wooden objects, which survived in the conditions of the heightened stagnant moisture of swampy and clay soils of these areas characterized by moderate climate, and the neolithic articles found in lake deposits, preserved their appearance rather well, despite considerable changes in their chemical composition and the structure of the wood. As a rule, maximum moisture absorption and shrinkage of archaeological wood exceed, to a rather great extent, the limit figures of sound wood /1/, which in itself is indicative of its degradation. We distinguish archaeological wood in a middle state of preservation with water content of under 70% (from the total weight of the wet wood) and wood in a poor state of preservation with the water content of over 70%. Normally, the leaf-bearing types are worse preserved with water content greater than in the coniferous ones.

In our work, the greatest content of water (93%) turned out to be in the aspen stake from the neolithic stand in Usvyaty. Its wood was very soft, the water could

be squeezed out of it like it were a sponge. After drying at room atmosphere the diameter of the stake contracted becoming three times as small. The conservation of such archaeological finds with the aim to preserve their form, size and surface details is a rather complicated task. In what follows is given the description of methods used in the State Hermitage Museum.

a. Drying under room conditions and slow drying

In the years 1956-59 a number of objects excavated in Pskov and Staraya Ladoga were dried at room atmosphere. The water content of the wood did not exceed 70%. The examination undertaken in 1971 showed that objects made of whole logs (sticks, treenails, stakes, etc.), and plane objects cut out of the middle part of the trunk (boards, bottoms, spades) had a well preserved shape. Objects having a curved surface (bowls, bailers, spoons, balls) became cracked and deformed. Boxtree and juniper were preserved best of all, somewhat worse being the case with pine-wood. A kind of contraction with some annual rings coming apart and the formation of radial cracks, sometimes very deep ones, were marked on some birch and fir-wood finds. As to oak-wood objects, some were well preserved, others became warped and cracked. In many cases the surface of the dried articles had small transversal cracks and flaked off.

Only little success was achieved in trying to prevent deformation and cracking when drying was slowed down with the help of polyvinylbutyral film bags or covering the object

with 8% polyvinylbutyral alcohol solution which forms a coagulated film on the surface of the wet object

To preserve the unearthed wood wet we recommend to wrap up the object in a piece of gauze moistened in 5% of the antiseptic - sodium pentachlorophenate water solution and place it into a well-sealed polyethylene bag

b Substitution of water for glycerol with polyvinyl alcohol

To stabilize water-logged archaeological wood the head restorer of the State Hermitage E A Rumyantsev suggested in 1955 the method of partial substitution of water for glycerol [2]. The objects were immersed into 20-40% glycerol solution containing 2% of polyvinyl alcohol. The solution was regularly heated up to 60-70°C during 8-9 hours a day. The impregnation continued until the weight of the object became constant, with drying in polyvinylbutyral film bags following. Such treatment results in the substitution of about 30% of water in the wood for glycerol. This proves to be sufficient to prevent warping and cracking of the wood with water content under 70%. For badly affected wood of leaf-bearing types with water content of 85-90% this kind of treatment, however, is little efficient. In such cases the glycerol concentration should be increased up to 70%, but the object becomes dark, greasy to the touch and moist at increased humidity. The polyvinyl alcohol slows down the evaporation of water from the object and somewhat consolidates the wood. We showed that optimal results can be obtained when using 50% of glycerol solution with 6% of polyvinyl alcohol.

57 finds from Pskov treated in 1956 according to Rummyantsev's method were examined in 1971. It turned out that 37 objects made of coniferous and leaf-bearing types / including fir-wood and birch / and kept during 15 years under normal museum conditions have good appearance without cracks and warping. Among them sticks, boards, bottoms, treenails, churn-staffs, beetles, bowls and balls. 12 objects are marked with small longitudinal cracks. 8 largest ones cracked and became deformed, insufficient introduction of the solution evidently accounting for it in 4 cases.

Thus, the treatment according to Rummyantsev's method stabilizes wet archaeological wood in the middle state of preservation for many years, though it does not provide the object with the desired consolidation and satisfactory appearance. High hygroscopicity ^{of glycerol,} is the main drawback of this method.

c. Oil-resin treatment (Polish method)

Since 1959, after some experimental tests, a method borrowed from the Polish restores has been applied in the Hermitage /3/. According to it, wet archaeological wood is soaked with a solution, heated to 60-70 °C, of 75 weight parts of turpentine, 25 - of linseed-oil, 5 - of rosin and 5 parts of 30% alcohol solution of the antiseptic carbolineum. (In our work carbolineum is substituted for phenol). The major part of the object is brushed with the mixture or kept immersed in it until saturation is reached. The process has been found to be accelerated if the soaking is carried on alternately with hot and cold solutions. The surplus of the solution is removed from the surface with monomethyl cellosolve. Such a treatment re-

sults in polymerized linseed-oil /linoxin/ and rosin remaining in the wood. According to the data obtained in our studio, the dry residue amounts to 60-70% of the mass of the object treated. The treatment lasts 7 -10 days, for large articles it takes more time. In the course of drying of large objects in birch, fir- and oak-wood there sometimes arise longitudinal cracks. In other cases cracking and deformation have not been observed. The wood becomes more solid, its surface appearance light and natural. Our experience proved the efficiency of this method for wood in the middle state of preservation with water content under 70%. The recent examination of more than 150 objects treated according to this method in 1959-60 showed that at present by far the greatest part of them is in good condition.

d. Polymerization Butyl methacrylate inside the wood

This method of wet archaeological wood conservation was worked out by the head of the State Hermitage chemical laboratory I.L.Nogid in 1964-66 /4/. The water in the wood is substituted for acetone in succession with butyl methacrylate monomer, containing 0,3-1% of the initiator (benzoyl peroxide). The polymerization is carried on at 90-95 C during 6-8 hours, in a closed vessel with its volume 2-4 times exceeding that of the object. Part of the monomer introduced evaporates. The lowmolecular polybutyl methacrylate formed inside the wood makes up 60-70% of the mass of the object treated. The polymer solidifies the wood; its colour, texture and surface details are well preserved. If the surface is

not sufficiently saturated with resin, it is additionally fixed with the xylene solution of polybutyl methacrylate.

This method was applied in the treatment of neolithic wooden objects from Usvyaty, finds from Maly Toropetz site /XII century/ and from Novgorod /XII century/ - altogether about 100 objects of different shapes and purposes (beetles, spoons, arrows, bowls, balls, etc.). The water content in these objects amounted to 60-90%. The main types of wood are oak, maple, birch, pine, fir. The results of the treatment and recent examination of the objects which underwent conservation in 1965-66 lead to the conclusion that this method is particularly good for the preservation of objects in oak. In the process of treatment it was only in 3 out of 50 neolithic finds (beetles and others) that longitudinal cracks were formed. Shrinkage does not exceed the normal one; after treatment fragments of one object joint well. During 5-6 years after the treatment nearly all objects remained without any changes, the formation of a fresh longitudinal crack being observed only in one beetle. Less satisfactory are the results of the treatment of other leaf-bearing and coniferous types of wood. The objects shrink more, sometimes they warp and crack. In some neolithic pine-wood objects the annual rings became separated. Thin objects in maple (e.g. the oar blade) undergo a substantial shrinkage and warping. This high temperature treatment is not to be recommended at all for thin articles whose surface is large in comparison with their volume.

e. Impregnation with polyethylene glycols

Since 1963 the method of preservation and stabilizing ar-

archaeological wood with synthetic water soluble waxes - polyethylene glycols has been investigated and for some years widely applied in the Hermitage /5,6/. We use polyethylene glycol with the molecular weight 1500 and melting point 42-46⁰ C. The objects are immersed into a bath with 5-10% polyethylene glycol solution. The bath is heated at regular intervals with infra-red lamps during 7-8 hours a day. The temperature is gradually increased from 35 to 70⁰ C. The solution is added from time to time so that the level of the solution in the bath should remain constant. The treatment is complete when the polyethylene glycol remaining in the bath contains about 5% water. The treatment of small objects continues for 3-4 months, the larger ones need more time. At the beginning the drying is slowed down. As the result of such treatment, 85-100% of the wood pores are filled with polyethylene glycol which stabilizes the size and shape of the archaeological wood and makes it strong and durable enough to be preserved under museum conditions.

A formula has been suggested by the authors to estimate the degree of the substitution of water in the wood for polyethylene glycol (the degree of pore filling) in the case when it is impossible to determine the water content in the wood by drying the sample of the wood. The substitution degree

$$N = \frac{V}{V_1} \cdot 100\%,$$

V being the water volume in the wet object, v - the polyethylene glycol volume after treatment. V and v can be calculated if the mass of the water saturated object (m_1), its mass after the impregnation (m_2), the mass after the evaporation of the remaining water (m_3) and the density of polyethy-

lene glycol (d) are known. The water density is taken to be equal 1. Indeed, if m is the mass of the air-dry wood in the object, it follows that:

$$m_1 = m + V$$

$$m_2 = m + V - v + d \cdot v = m + V + (d-1)v$$

$$m_3 = \frac{m + d \cdot v}{m_2 - m_1}$$

whence

$$N = \frac{m_2 - m_1}{m_3 - m_1 + d(m_2 - m_3)} \cdot 100\%$$

The values of N obtained by this formula are close to those calculated by the formula applied in cases when the percentage water content in the wood ($w = \frac{m_1 - m}{m} \cdot 100\%$) was estimated by drying the sample of the wood:

$$N = \frac{100m_3}{w + m_1 \cdot d} \cdot \frac{(100 - w)}{m_1} \cdot 100\%$$

With polyethylene glycol 1500 were treated a maple ore with a carved handle and the handle in the shape of a bear's head from an alder bailer (neolit, Usvyaty), as well as a Novgorod psaltery XII century in juniper-wood with thin artistic carving, and other objects. Their shape and all other surface details are well preserved. We think, that polyethylene glycol treatment can be successfully applied to the archaeological wood in any state of preservation and shape.

At present we give preference to the polyethyleneglycol treatment as the most universal and reliable technique, though the treatment takes a long time. We use the polish method for the conservation of domestic articles in a rather good state of preservation and not having any artistic value. The method of monomer polymerization inside the wood has a restricted application. Glycerol treatment has not been used since 1959.

lately, some articles have been cleaned of glycerol and treated otherwise

The work for the further perfectioning of the conservation technique is being carried on

B. Charred carved wood

Since 1951 a large number of charred fragments of carved wood have been excavated in Middle Asia / Pjandzikent, Shahristan and others / In VII-VIII centuries wooden articles together with mural paintings and sculptures decorated temples and houses. All these samples - fragments of friezes, capitals, sculptures and utensils - turned into char-coal as a result of fires in conditions of limited air access, preserving the shape and details of the carved surface.

Char-coal is a chemically stable substance but it is brittle. It is nearly impossible to take charred objects out of the earth without fixing. That's why conservation work is advisable to begin in the field. In field conditions large charred objects, as they are carefully relieved of the earth, are poured over with boiling paraffin, then wrapped up in several layers of gauze fixed with paraffin. In the conservation studio, the paraffin is smelted away, the object is thoroughly cleaned and finally fixed with wax and rosin mixture (1:1), care being taken not to change the texture of the char-coal. Cracks and gaps are filled with the mixture of char-coal powder in polybutyl methacrylate acetone solution. If necessary, the object is mounted on a hard support (wooden, foam-resin). /8/ More than a hundred most valuable relics of wood carving have been extracted from obstructions and were fixed. Now a

part of them is displayed at the Middle Asia culture and art exhibition in the Hermitage and in the Academy of Sciences Historical Institute of the Tajik SSR in Dushanbe.

In some cases, for treatment of thin charred objects of small size, polybutyl methacrylate solution may be used. 15-20% acetone solution forms an enveloping film which allows to take the object quickly out of the ground. In the studio the film is dissolved, the object is carefully cleaned and impregnated with the same resin in xylene (25-30%). The impregnation is made with a brush or by immersing into a bath, if possible.

If the condition of the char-coal allows to immerse it into a bath for impregnation, sometimes it is advisable to introduce a butyl methacrylate monomer into it and then polymerize it inside the char-coal. A similar technique is used for the preservation of wet archaeological wood /4/. For charred wood an optimal method of impregnation and polymerization has been worked out /9/. It is advisable to impregnate the char with a monomer by immersing it into a bath without any access of light during 20-40 hours or in vacuum during 20-50 minutes. Then the objects are kept in a thermostat at 106⁰ C during 7 hours, with slow cooling following. Such treatment results in the char-coal weight increasing 1,8-2 times, the desired strength of the object being achieved.

This technique permitted to treat thin charred wooden plates with pictures carved with the edge of a knife, as well as small charred vessels and figurines of animals. Small fragments of these objects were discovered by the Krasnoyarsk ex-

pedition of the USSR Academy of Sciences in a burnt underground vault and brought to the studio without previous treatment. After treatment the fragments were sorted out according to the design, stuck together with the polybutyl methacrylate acetone solution; the parts of the objects which could not be cleaned before fixing were cleaned. The plates thus assembled are 60-100 cm in length.

The choice of the treatment technique depends on the character, size and conditions of the relics discovered.

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rogramme "NUCLEART"

UTILISATION DU
RAYONNEMENT GAMMA
POUR LA CONSERVATION DES
BIENS CULTURELS

LES BOIS GORGÉS D'EAU

COMMISSARIAT A L'ENERGIE ATOMIQUE
SECTION D'APPLICATION DES RADIO-ELEMENTS
CONSEIL INTERNATIONAL DES MUSEES (ICOM)



COMMISSARIAT A L'ENERGIE ATOMIQUE

Département des Radioéléments

Section d'Application des Radioéléments

CONTRIBUTION A L'ETUDE ET AU TRAITEMENT

DES BOIS GORGES D'EAU

B. Détanger et L. de Nadaillac

8981 40

Rapport n° SAR-G/72-20/1

Août 1972

CONTRIBUTION A L'ETUDE ET AU TRAITEMENT DES BOIS GORGES D'EAU

Dès le début de notre étude sur les possibilités d'une action dans le domaine de la conservation des biens culturels, nous nous sommes aperçus que l'on citait souvent la sauvegarde des bois gorgés d'eau comme étant un problème important et relativement urgent. Nous avons alors essayé de savoir pourquoi les méthodes de traitement existantes n'avaient pas résolu cette question en recueillant les avis de nombreuses personnes. Devant la grande divergence des opinions et des tendances, la variété des critères de choix ou de rejet de l'une ou l'autre méthode, nous avons du prendre le problème de façon plus systématique, et établir un plan de travail.

La première partie devait nous permettre de faire plus amplement connaissance avec ce matériau assez nouveau pour nous. Le Service des Fouilles et Antiquités du Ministère des Affaires Culturelles nous a alors aimablement fourni des bois provenant du gisement de Chamalières sur lesquels nous avons pu procéder et faire procéder à un certain nombre d'études.

La seconde partie a pour objectif la meilleure connaissance des techniques de traitement actuellement connues. Elle doit nous conduire à l'établissement d'un tableau des avantages et des inconvénients de chaque méthode selon un grand nombre de critères. C'est grâce à l'aide du Centre International d'études sur la Conservation et la Préservation des Biens Culturels (Rome) que nous avons pu profiter des enseignements d'une enquête lancée par ce Centre.

La troisième partie doit nous conduire à la mise au point d'une technique nouvelle, plus sûre, plus économique, et d'emploi plus facile. Une méthode sur laquelle nous essayerons de regrouper au maximum les avantages, en éliminant le plus possible les inconvénients, signalés par l'enquête sur les autres procédés. Cette mise au point devra normalement se poursuivre par une série de traitements expérimentaux permettant d'établir des "modes d'emploi" adaptés aux

différentes variétés du matériau.

A. ETUDE DU MATERIAU .

Divers organismes ont apporté et apportent encore leur concours à cette partie de notre programme. Ce sont : Le Centre Technique de l'Industrie des Papiers, Cartons et Celluloses, le Service des Fouilles et Antiquités déjà cité, le Centre de Recherches sur la Conservation des Documents Graphiques l'Institut Pasteur et le laboratoire d'Hygiène de la Ville de Paris.

a. Etude Botanique et Physico-Chimique.

- Les quatre échantillons ayant servi à cette étude étaient des feuillus, selon toute vraisemblance : Saule ou Peuplier, Bouleau, Hêtre ou Frêne. Ils étaient dans un état de dégradation avancée, présentant le plus souvent l'aspect d'un tissu spongieux envahi de microorganismes. On y a remarqué des cristaux très nombreux se présentant en macles de plusieurs millimètres. On peut également noter que la cohésion de ces échantillons varie beaucoup d'un endroit à l'autre d'un même morceau.

Les analyses chimiques ont été effectuées sur un prélèvement moyen de chaque échantillon après séchage à l'air et mise en sciure (appareil Wiley, Tamis 2, ouverture de maille 2mm environ). Les résultats reflètent donc la composition moyenne de chaque bois, sans tenir compte des différences pouvant exister entre les zones plus ou moins altérées.

Les analyses effectuées sont les suivantes :

- Sur échantillons bruts : siccité, après séchage à 105°C.

- Sur les sciures :

-Cendres à 800°C : analyse du Fer, Calcium, Aluminium, Magnésium, par spectrophotométrie d'absorption atomique, et Silice par gravimétrie.

-Insoluble dans l'acide sulfurique à 72%, assimilé à un "taux de lignine" (Norme AFNOR T-12 0 14). Cette analyse est faite après extraction à l'eau chaude au Soxhlet, l'insoluble étant corrigé du taux de cendres résiduelles.

-Polyosides, par chromatographie en phase gazeuse des dérivés silylés après hydrolyse complète des échantillons et réduction des polyosides à l'état d'oses simples.

- Enfin, on a recherché et dosé les polyosides dans l'extrait à l'eau bouillante des différentes sciures.

Les résultats de ces analyses figurent dans le tableau 1, ils appellent les remarques suivantes :

1. Les quatre échantillons contiennent des quantités très importantes de matières minérales, principalement du fer et de la silice.
2. Les extraits à l'eau chaude, au soxhlet, sont anormalement élevés, notamment sur P 3-3. Leur composition n'a pas été étudiée.
3. La fraction polyosidique des quatre bois a subi une forte dégradation puisqu'elle ne représente plus que 16 à 30% des échantillons, alors que les bois frais en renferment habituellement 65 à 80%. On retrouve après hydrolyse les cinq sucres présents habituellement dans les bois frais : glucose, galactose, mannose, arabinose, xylose, ainsi que les traces d'un autre sucre (rhamnose ou fucose). On note, par rapport à un bois frais, un enrichissement relatif très important en galactose, mannose et arabinose, sucres constitutifs, avec le xylose, de la fraction "hémicellulose". Les taux de glucose et xylose habituellement prédominants, sont de ce fait, très inférieurs aux valeurs normales, dont on trouvera quelques exemples dans le tableau 2. Par contre, les polyosides des extraits à l'eau bouillante ont une composition semblable à celle que l'on obtiendrait avec un bois frais : l'arabinose et le galactose, pouvant provenir des arabinogalactanes, sont extraits en priorité. De plus, il y a peu de glucose, ce qui ferait penser que ce sucre provient bien de la cellulose.

La composition anormale de la fraction polyosidique pourrait provenir entre autres causes :

- de la dégradation sélective de certaines parois de fibres, ayant préservé, pour des raisons diverses, des zones riches en hémicelluloses (protection par la lignine, par exemple).

- de l'attaque sélective de certains polyosides par des microorganismes ayant des métabolismes divers,
 - de la prolifération de microorganismes dont le contenu cellulaire serait particulièrement riche en galactose et arabinose.
4. Les taux de lignine sont anormalement élevés, les bois frais en renfermant habituellement de 15 à 30%. Cette fraction a beaucoup mieux résisté à la dégradation que la fraction polyosidique. Toutefois, le noircissement des bois, l'état pulvérent des sciures et le comportement de l'échantillon au cours du dosage, font penser que cette lignine a très certainement subi des modifications.

b. Etude des microorganismes.

L'étude photomicrographique ayant montré la présence de nombreux microorganismes, il nous a semblé utile de préciser nos connaissances sur ce point.

1. Champignons et moisissures.

Le service de Mycologie du Museum de Paris a identifié dans les échantillons étudiés les espèces suivantes :

- Aspergillus versicolor
- Penicilium vermiculatum
- Penicilium crusotum
- Penicilium cyclopium
- Penicilium frequentans
- Cladosporium herbarum

2. Bactéries et virus.

Les échantillons étudiés ne contenant pas de virus mais d'assez nombreuses bactéries dont la détermination n'est pas actuellement terminée.

Cette étude physico-chimique nous ayant donné un aperçu rapide des propriétés du matériau, nous avons cherché à extraire de l'enquête effectuée par le Centre International de Conservation (Rome) des informations concernant les méthodes de traitement actuellement employées.

B. LES METHODES ACTUELLES DE TRAITEMENT.

Il faut bien dire que cette enquête n'a pas, jusqu'ici, donné les résultats attendus. Le nombre encore insuffisant des réponses, les difficultés éprouvées par certaines des personnes interrogées pour estimer

TABLEAU I : Résultats des analyses

Echantillon n° :	P 2-3	P 3-3	O 4-3	M 3-3
Nature probable du bois :	Saule ou peuplier	Bouleau	Hêtre	Frêne
Siccité : % sur brut :	19,1	25,9	27,4	39,7
Composition du bois anhydre :				
Cendres à 800°C :	22,5	39,5	28,5	22,2
Lignine :	62,5	41	53	60
Extrait à l'eau (Soxhlet) :	12,5	35	11,7	7
Polyosides totaux :	25,5	16	29,5	25
Fraction polyosidique : comp. relat. %				
Glucose :	50,5	58,5	42	43,5
Galactose :	5	5,5	11	14
Mannose :	5,5	5,5	12	14
Arabinose :	20	20,5	19,5	12,5
Xylose :	19	10	15,5	15,5
Fraction minérale : en % des cendres .				
Fer :	29	12	29,4	25
Calcium :	7,5	4,4	3,8	6,4
Aluminium :	2	3,7	2,1	0,7
Magnésium :	0,9	1,1	0,6	0,8
Silice (SiO ₂) :	27,4	43	30,4	29,1
Fraction polyosidique de l'extrait à l'eau bouillante .				
Polyosides : % bois	6	3	7	3,3
Composition relative : %				
Glucose :	4	6	3	3,5
Galactose :	11,5	25	19	17
Mannose :	1,5	4	3,5	3
Arabinose :	63,5	42,5	61	70,5
Xylose :	19,5	22,5	13,5	6

TABLEAU 2

Composition en sucres des bois
frais (en %).

Nature du bois.	Xylose	Glucose	Galactose	Mannose	Arabinose
Bouleau :	39	58,5	1,5	0,5	0,5
Tilleul :	34,5	58,5	1,5	3,5	2
Erable :	32,5	60,5	2	4	1
Hêtre :	28	65	4	1,5	1,5
Chêne :	26	68,5	2,5	2	1,5
Frêne :	32	60,0	3	2,5	2,5
Saule :	26	74	3	2,5	1
Orme :	27	68,5	2,5	2	1
Aulne :	27	67	3,5	1,5	1

l'usure des récipients en oubliant le coût de la main-d'oeuvre, la relative imprécision et la subjectivité des réponses font qu'il est actuellement difficile d'en tirer plus que des tendances et des impressions. On peut souhaiter que, soit par de nouvelles réponses, soit par l'amélioration de celles déjà parvenues, cette entreprise prenne toute sa valeur et tout son intérêt. Cependant on peut d'ores et déjà esquisser le tableau des méthodes actuelles de traitement. Les plus fréquemment citées sont dans l'ordre : Arigal C, Polyéthylène-Glycol, Alcool-Ether-Résine, d'autres comme le séchage à froid par le Butanol tertiaire, ou encore l'utilisation des sels de Chrome, peu nommées, doivent être considérées comme expérimentales. Enfin, plus personne ne parle de techniques plus anciennes comme, par exemple l'utilisation de l'Alun.

a. Traitement par l'Arigal-C.

On immerge le bois dans une solution aqueuse contenant 25% d'une résine Mélamine-Formol jusqu'à ce que le bain soit devenu homogène, on condense ensuite par action d'un catalyseur le produit imprégnant. Celui-ci étant complètement insoluble, la méthode n'est donc pas réversible. Malgré la relative légèreté du matériau obtenu, la consolidation des pièces de taille moyenne est satisfaisante, leurs dimensions sont maintenues à environ 1% près, et leur aspect est qualifié de trop clair. Le traitement nécessite quelques précautions, en particulier, du côté de la température et du pH. Pour un objet de 2 dm³ sa durée est de deux mois environ, temps de séchage en plus, le prix des produits varie, selon les estimations de 30 à 100 Frs, et le nombre d'heures de personnel relativement spécialisé de 1 à 40 ! Ce qui conduit à une estimation du coût de traitement de 30 à 430 Fr le dm³, non compris les amortissements et les consommations de fluides divers. Pour des lots d'objets plus importants traités en une seule fois, 100 dm³ par exemple, on obtient de la même façon un prix de 20 à 40 Fr le dm³.

b. Traitement par le Polyéthylène-Glycol (PEG 4000).

On immerge le bois dans une solution aqueuse de Polyéthylène-Glycol puis on élève progressivement la température jusque vers 60°C, l'eau de la solution et du bois s'évaporent lentement et la concentration de cire dans le bois augmente. Après refroidissement on nettoie l'objet (avec du Toluène par exemple). Le maintien de la forme est assuré dans d'assez bonnes conditions, la couleur finale est très foncée et le poids élevé, l'aspect peut être parfois un peu collant. Il apparaît souvent des fentes dans les pièces plus importantes. La durée du traitement est beaucoup plus longue que dans la technique précédente. Cette méthode réversible (au moins partiellement) est vraisemblablement un peu moins chère que l'utilisation de l'Arigal C, étant aussi plus aisée son emploi est très fréquent. Une variante dans laquelle l'eau est remplacée par du Méthanol a été expérimentée, les déformations semblent moindres qu'avec l'eau et la vitesse de traitement est plus grande.

c. Traitement par l'Alcool-Ether-Résine.

Cette technique se déroule en deux étapes. Tout d'abord on remplace par des bains successifs l'eau contenue dans le bois par de l'alcool. Puis cet alcool par de l'éther dans lequel a été dissoute une résine naturelle ou non. On procède alors à l'évaporation de l'éther (éventuellement par un vide partiel) qui dépose cette résine dans les canaux du bois en le consolidant. L'enquête a donné peu de réponses sur cette méthode qualifiée d'expérimentale, assez chère et un peu dangereuse. Les résultats obtenus semblent excellents, l'aspect du bois très naturel, les dimensions bien conservées. Toutefois comme pour le traitement au Polyéthylène-Glycol les indications fournies sont insuffisantes pour permettre une estimation même sommaire du coût de la consolidation.

En attendant de pouvoir tirer de cette enquête des résultats plus constructifs nous avons commencé à définir un programme de recherches.

C. ESSAI DE DEFINITION D'UNE ORIENTATION NOUVELLE .

Il nous est apparu que le problème pouvait être décomposé en deux parties : le remplacement de l'eau et le durcissement du matériau substitué. Dans le cas où l'on choisit comme produit imprégnant une résine polymérisable par l'action du rayonnement γ les deux problèmes cités sont suffisamment modifiés pour justifier l'étude d'une éventuelle méthode de traitement.

Pour obtenir de bonnes qualités du produit traité il nous semble important de substituer la plus grande partie de l'eau (ce qui n'est pas le cas dans la méthode à l'Arigal C) par un produit, évidemment durcissable, de masse moléculaire et de viscosité aussi faibles que possible afin de bénéficier d'une plus grande vitesse de traitement (ce qui n'est pas le cas du PEG 4000). Ce produit d'imprégnation doit être soluble dans l'eau soit naturellement, soit par l'intermédiaire d'un artifice. Enfin pour augmenter la concentration dans l'objet, il est nécessaire de savoir extraire l'eau de ce produit.

De plus, l'emploi du rayonnement γ pour initier la polymérisation d'un monomère, jusque là pratiquement inerte, permet d'éviter les inconvénients de l'action difficile d'un catalyseur provenant de l'extérieur. En effet, dès que la polymérisation des couches externes de l'objet devient importante la pénétration du catalyseur nécessaire au durcissement des couches internes devient beaucoup plus difficile. Ce phénomène risque de provoquer de mauvaises consolidations internes dans les bois de taille plus importantes.

Ces considérations nous ont amené à étudier deux directions de traitement :

a. Une méthode de substitution Eau-Solvant-Monomère empruntée aux travaux de M. Munnikendam et M. de Guichen, destinée à nous permettre de vérifier l'intérêt de l'emploi du rayonnement γ pour la partie polymérisation. Les couples choisis furent :

- Eau-Acétone-Styrène/Polyester.
- Eau-Ethanol-Métacrylate de Méthyle.

Dans les deux cas le rapport des poids après traitement aux poids avant traitement ont été de l'ordre de 0,9, les dimensions ont été maintenues à mieux que 2% près. Le matériau traité présente un aspect excellent et une très grande stabilité dans le temps. Cependant le traitement est assez long, consomme une quantité importante de solvant (environ 25 fois le volume du bois) et de monomère (environ 15 fois le volume). On pourrait envisager éventuellement un retraitement du monomère pour en extraire le solvant et diminuer le prix de revient.

b. Une méthode d'extraction Liquide-Liquide dans laquelle le monomère est rendu artificiellement soluble dans l'eau par adjonction d'une petite quantité de solvant. On est alors devant un système qui en présence d'eau se sépare en deux phases : l'une contient la quasi-totalité de l'eau, un peu de solvant et des traces de monomère, l'autre ne contient pratiquement pas d'eau et peut être recyclée. C'est dans cette voie que nous nous sommes engagés.

D. MISE AU POINT D'UNE TECHNIQUE DE TRAITEMENT PAR EXTRACTION

LIQUIDE-LIQUIDE .

Pour cette direction de recherche, il faut avant tout faire le choix du système Solvant-Monomère. Ce choix se fait à partir des diagrammes de solubilité ternaires. La littérature étant presque muette sur ce sujet, nous avons commencé par tracer ces diagrammes point par point à partir de mélanges de composition connue (Voir figure 1). C'est ainsi que nous avons étudié les systèmes :

- Eau-Ethanol-Styrène.
- Eau-Méthanol-Styrène.
- Eau-Acétone-Styrène.
- Eau-Acétone-Styrène/Polyester, pour deux compositions de monomères.
- Eau-Ethanol-Metacrylate de Méthyle.
- Eau-Acétone-Metacrylate de Méthyle.

De ces diagrammes on tire ensuite les courbes de partage des solvants entre l'eau et le monomère choisi, (Voir figure 2). Puis on réalise des solutions correspondant à la composition moyenne du mélange qui imprégnera le bois en fin de traitement pour pouvoir étudier les conditions de polymérisation. Ces essais ont montré que la plupart des solutions envisagées donnaient des polymères dotés de propriétés mécaniques valables. Cependant le plus homogène et le plus stable a été le mélange Ethanol-Métacrylate de Méthyle qui même avec 10% d'alcool inclus ne voit pas son poids varier de plus de 1‰ après trois mois d'étuve à 65°C.

Ayant ainsi rassemblé des informations sur le polymère et sur la répartition du solvant entre les autres constituants, il importait de connaître la signification physique de ces dernières courbes. Pour ce faire, nous avons réalisé une installation pilote capable de traiter des objets de quelques litres, adaptable aux différentes solutions. (Voir figure 3). Deux séries d'expériences ont été réalisées avec les systèmes : Eau-Acétone-Styrène et Eau-Méthanol-Styrène. On note les résultats suivants :

- Système Eau-Acétone-Styrène : L'extraction est très rapide (environ 50% du poids initial du bois en 24h), mais les dimensions sont très altérées, jusqu'à 30% sur les mesures tangentielles.
- Système Eau-Méthanol-Styrène : Pas de variations de dimensions, mais pas d'extraction non plus !

Dans le premier cas on a visiblement un dessèchement trop rapide du bois, il semble donc qu'il faille s'orienter vers un système dans lequel le solvant soit le plus impartial possible vis à vis de l'eau et du monomère. Cette constatation nous conduit à utiliser le système Eau-Ethanol-Métacrylate de Méthyle.

Pour une composition initiale de : Métacrylate de Méthyle 85%, Ethanol 10%, Eau 5% (ce qui peut se produire au moment de la mise en place du bois), on rejète un mélange contenant seulement de l'eau, 7 % d'Ethanol et des traces de monomère. La figure 4 donne quelques

exemples de courbes d'extraction de l'eau pour des échantillons de volume et porosité divers. La figure 5 montre l'évolution des dimensions au cours du séchage, après traitement et polymérisation, dans une pièce dont la température est maintenue à 21°C (humidité non contrôlée). En effet, il n'apparaît pas nécessaire de remplacer la totalité de l'eau par le mélange polymérisable, car le temps de traitement deviendrait prohibitif. Nous nous sommes fixés, au moins dans une première étape, le remplacement de 60 à 70% de l'eau contenue initialement. Le matériau ainsi obtenu a une densité après séchage de l'ordre de celle du bois naturel, son aspect étant très voisin de celui d'un bois sec ancien.

E. PERSPECTIVES .

Dans les prochains mois nous comptons :

- a. Poursuivre les essais de ce système sur des bois variés, origine, état de dégradation, coeur et aubier, etc.
- b. Tester éventuellement d'autres couples solvant-monomère pour approfondir la question de l'impartialité du solvant vis à vis de l'eau et du monomère et essayer de réduire la tension de vapeur du mélange pour pouvoir extrapoler plus facilement vers une machine de plusieurs centaines de litres de capacité.
- c. Prolonger les essais de vieillissement naturel par des contraintes plus dures (chocs thermiques, variations rapides d'hygrométrie, etc...).
- d. Commencer des traitements expérimentaux sur des objets d'intérêt secondaire (fragments, pieux, etc).

F. CONCLUSIONS .

Les perspectives offertes par l'utilisation simultanée d'une technique d'extraction liquide-liquide de l'eau du bois et de la polymérisation sous rayonnement γ du monomère introduit en remplacement sont suffisamment intéressantes pour mériter d'être étudiées plus à fond.

Ses principaux avantages sont en effet :

1. Faible consommation de produits, limitée pratiquement à ce qui est introduit dans le bois.
2. Très bonnes qualités du matériau traité.
3. Reversibilité partielle suffisante pour pouvoir éventuellement dégager l'extérieur du matériau (dans les pièces importantes, supérieures à quelques dm^3 , il serait illusoire d'espérer extraire la totalité du polymère contenue, en particulier dans les régions centrales).
4. Possibilité d'automatisation presque complète du traitement.
5. Prix de revient tout à fait comparable à celui des autres techniques.

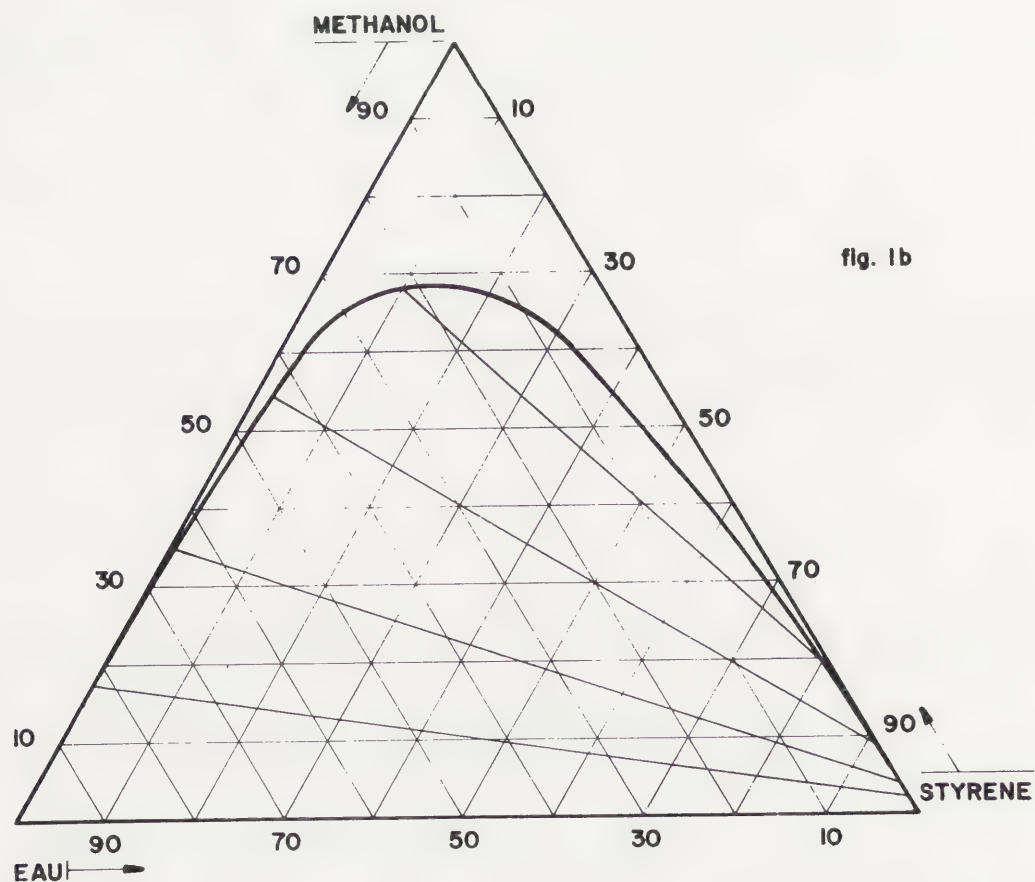
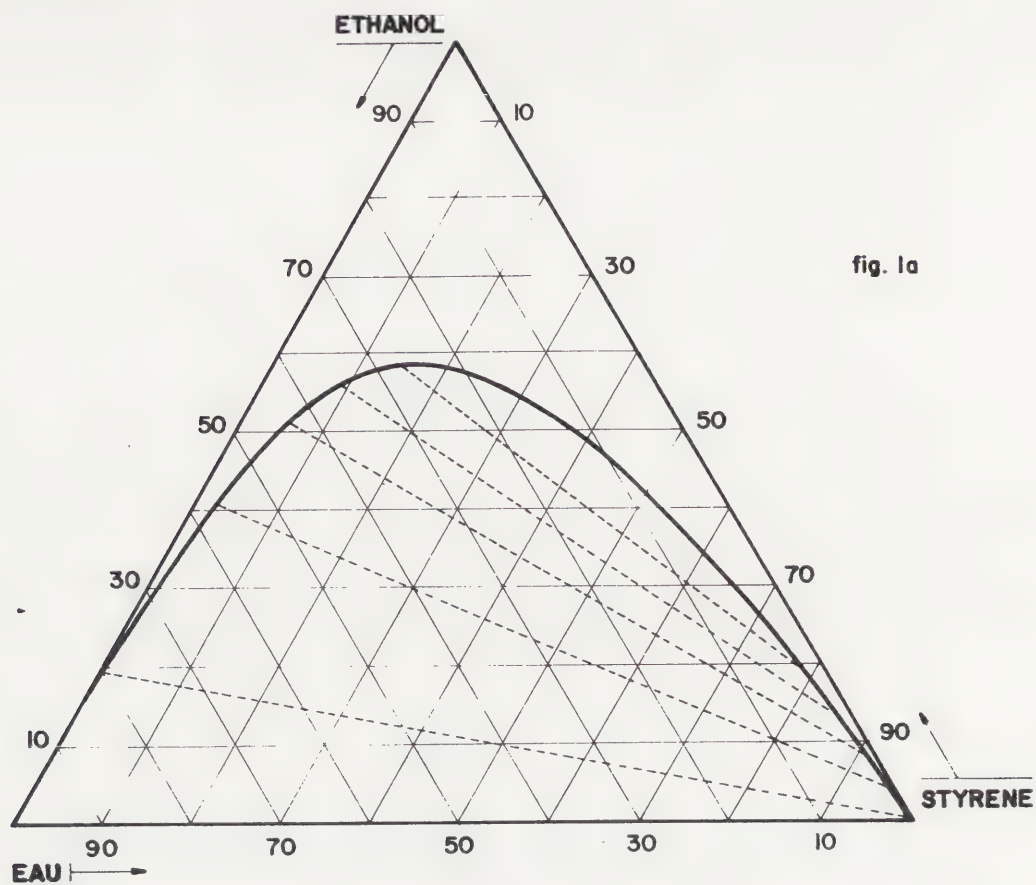
Il reste encore quelques inconvénients que nous nous efforcerons de réduire :

1. Longueur du traitement encore un peu élevée.
2. Réduction des dimensions de l'ordre de 2%, ce qui semble être trop important.

REMERCIEMENTS

Nous tenons à remercier ici toutes les personnes et tous les organismes qui nous ont apporté leur assistance pour la mise en route de ce programme et spécialement le Centre technique de l'industrie des papiers, cartons et celluloses (Grenoble), dont l'aide pour l'étude botanique et physico-chimique a été, comme l'on a pu se rendre compte, très importante.

DIAGRAMMES DE SOLUBILITE



DIAGRAMMES DE SOLUBILITE

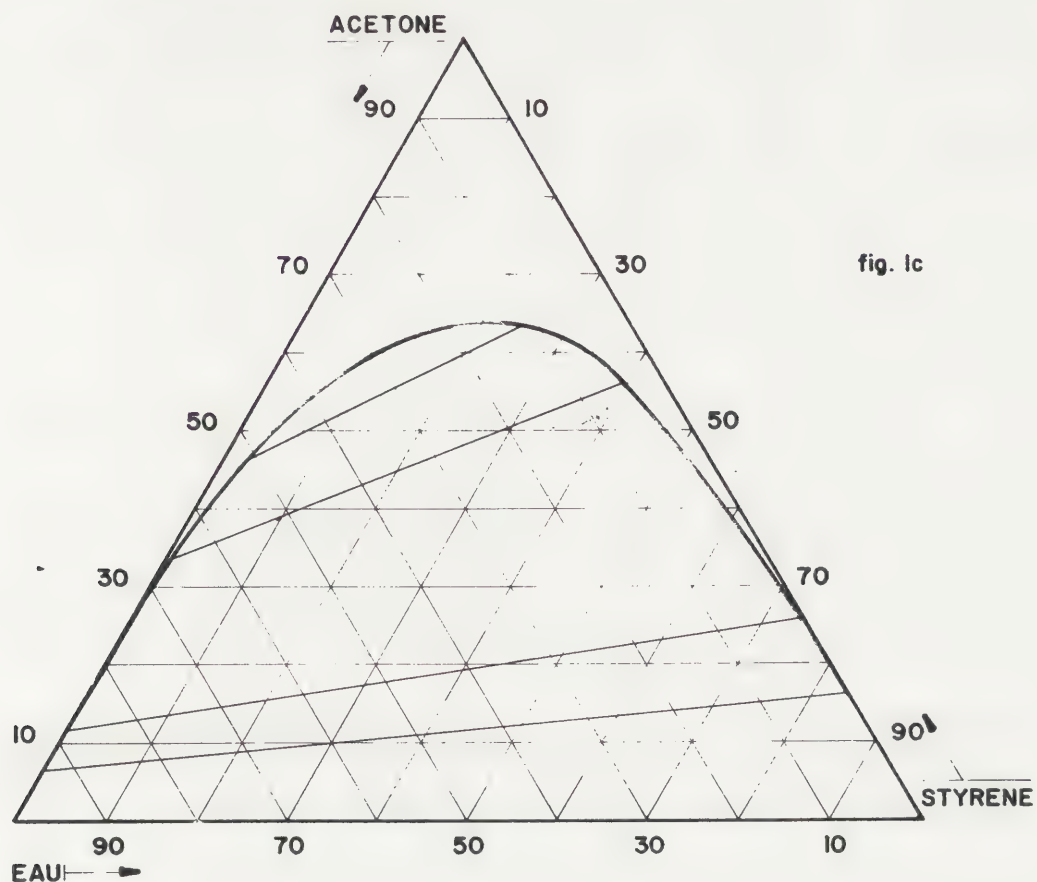


fig. 1c

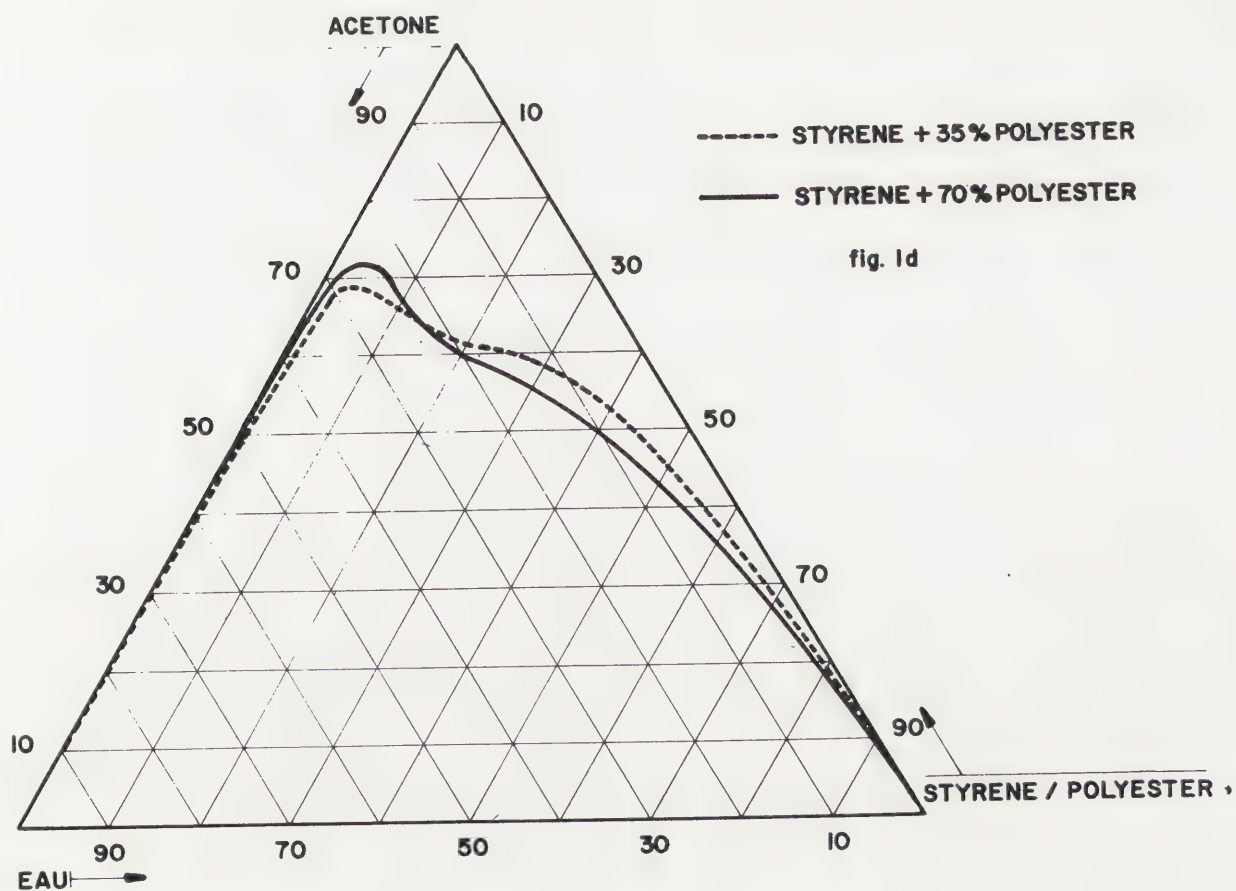


fig. 1d

DIAGRAMMES DE SOLUBILITE

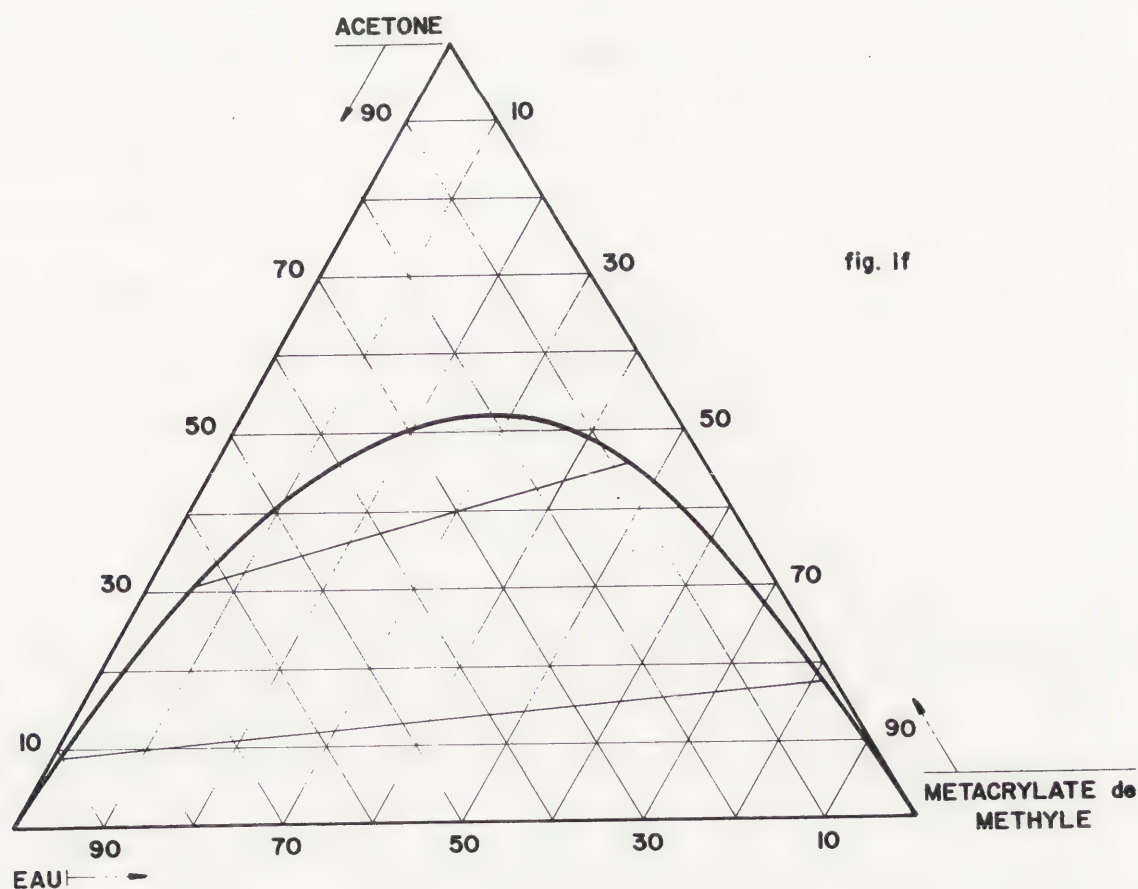
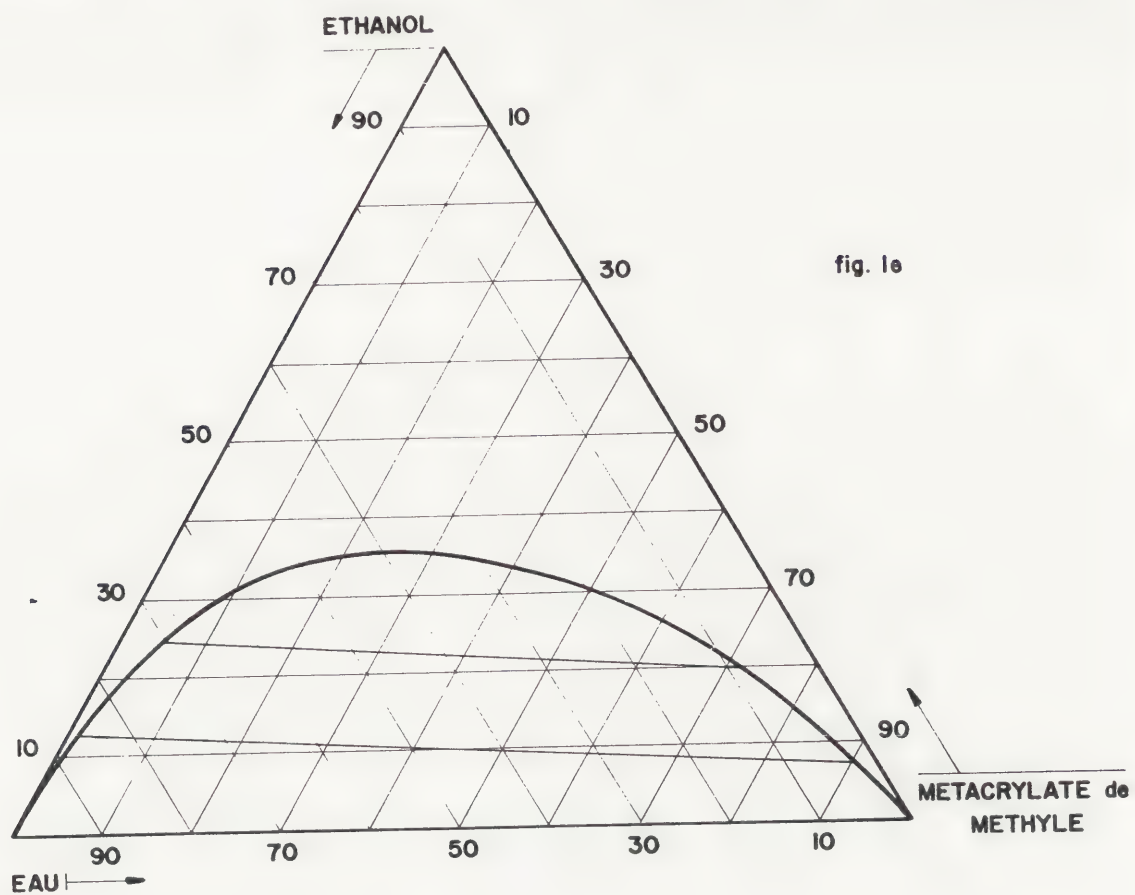
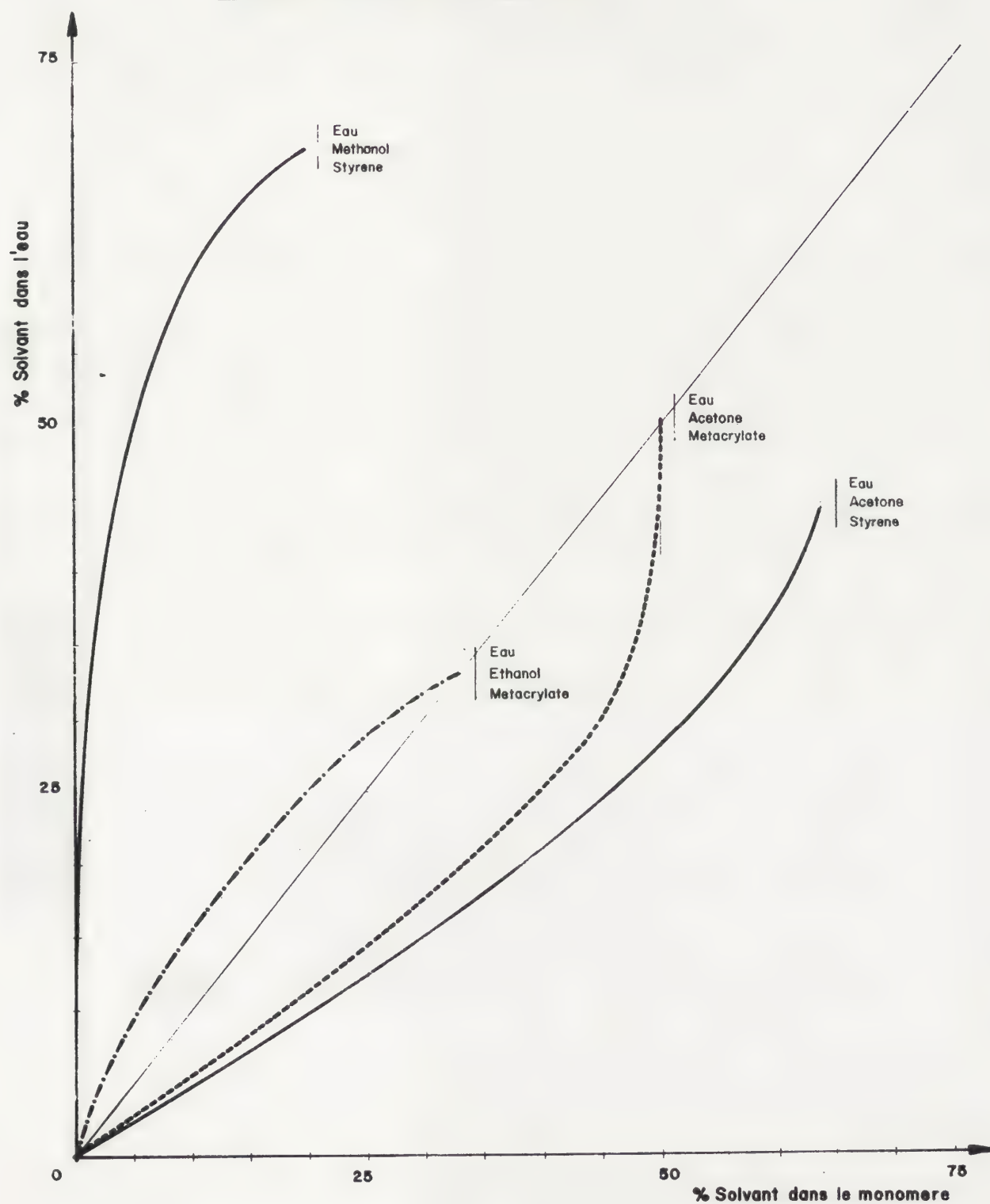


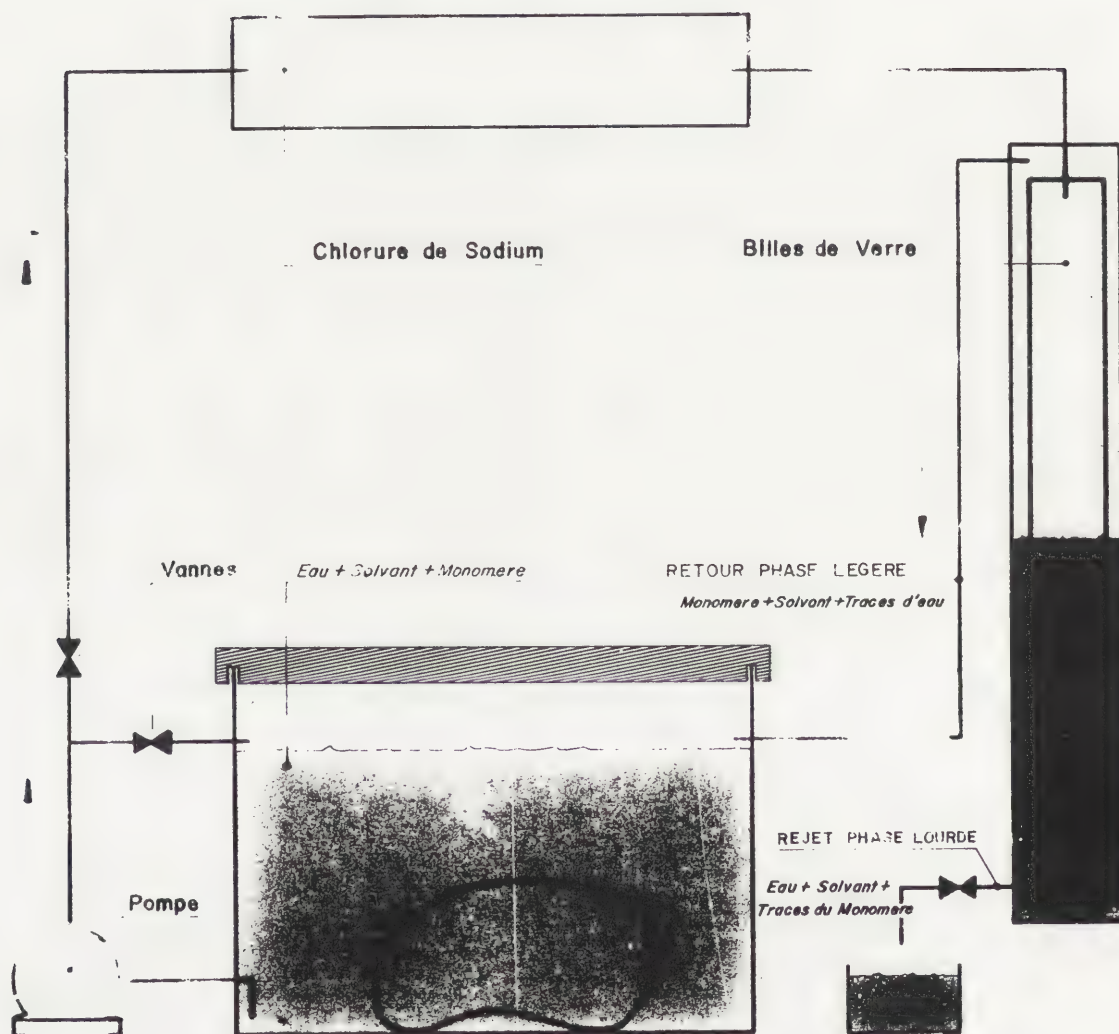
DIAGRAMME DE PARTAGE

fig. 2



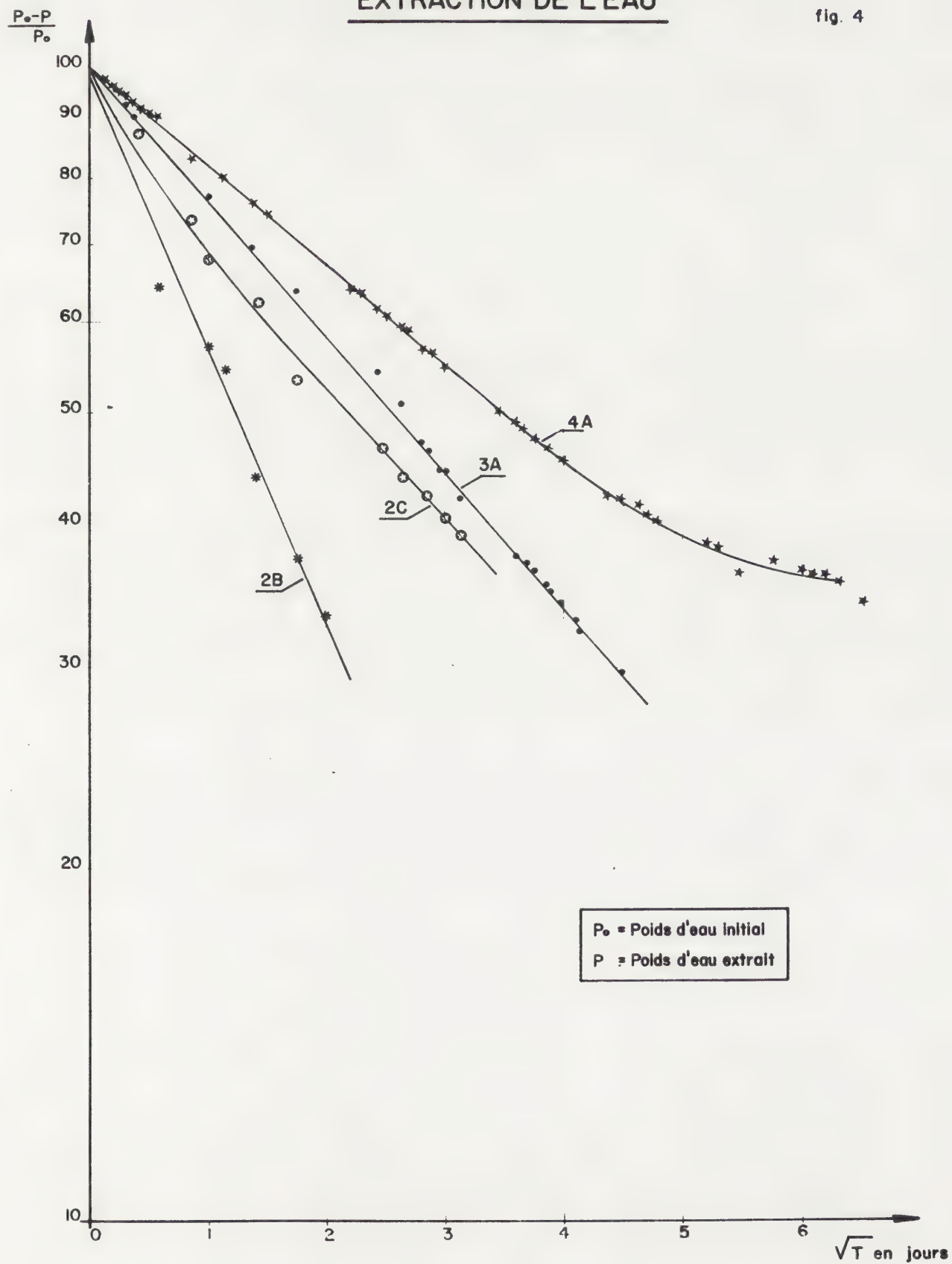
Schema de l'installation

fig. 3



EXTRACTION DE L'EAU

fig. 4



SECHAGE DES BOIS

fig. 5

Echantillons

P/P_0

Variations de Poids

2B

0,9
0,8
0,7

\sqrt{T} en Jours

2C

0,9
0,8

\sqrt{T} en Jours

3A

0,9
0,8

\sqrt{T} en Jours

Point de Mesure

Variations de Dimensions

2B

48
RI 47
mm 46
58
CI 57
56

\sqrt{T} en Jours

\sqrt{T} en Jours

2C

66
CI 65
64

\sqrt{T} en Jours

3A

104
CI 103
102

\sqrt{T} en Jours

ANNEXE 1

LES DIAGRAMMES DE SOLUBILITE TERNAIRES

L'étude des mélanges de trois corps liquides non miscibles en toutes proportions se fait sur un diagramme ternaire. Tout mélange ternaire M des constituants A, B, C est représenté par un point d'un triangle équilatéral (figure a). On a :

$$MA' + MB' + MC' = \text{Constante} = AH = 100\%$$

et :

$$\frac{MA'}{AH} = \text{Concentration du produit A} \quad , \quad \frac{MB'}{AH} = \text{Concentration du produit B, etc.}$$

Les zones du triangle où les trois constituants ne forment qu'une phase, c'est à dire sont parfaitement miscibles entre eux, sont séparés de celles où le mélange se sépare en deux phases par des courbes. Dans le cas qui nous intéresse cette courbe grossièrement parabolique passe pratiquement par les sommets du triangle : Eau et Monomère, la solubilité de l'un dans l'autre étant presque nulle. (Figure b). Si un mélange a son point représentatif dans la zone supérieure, les projections sur les trois côtés donneront la composition du mélange. Lorsque le point représentatif est dans la zone d'insolubilité le mélange se sépare en deux phases non miscibles entre elles. La composition globale reste représentée par M, les compositions des deux phases sont données par M_1 et M_2 , les trois points sont alignés sur une "droite de conjugaison" et les rapports :

$$\frac{M_2 M}{M_1 M_2} \quad \text{et} \quad \frac{M_1 M}{M_1 M_2}$$

représentent les quantités respectives des deux phases. Les droites de conjugaison sont pratiquement concourantes, l'une d'elles passe par le point critique où le mélange commence à devenir parfaitement miscible.

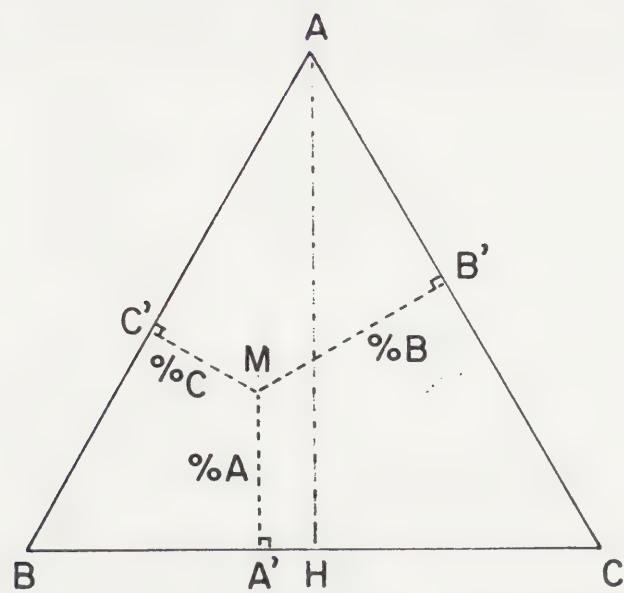


figure (a)

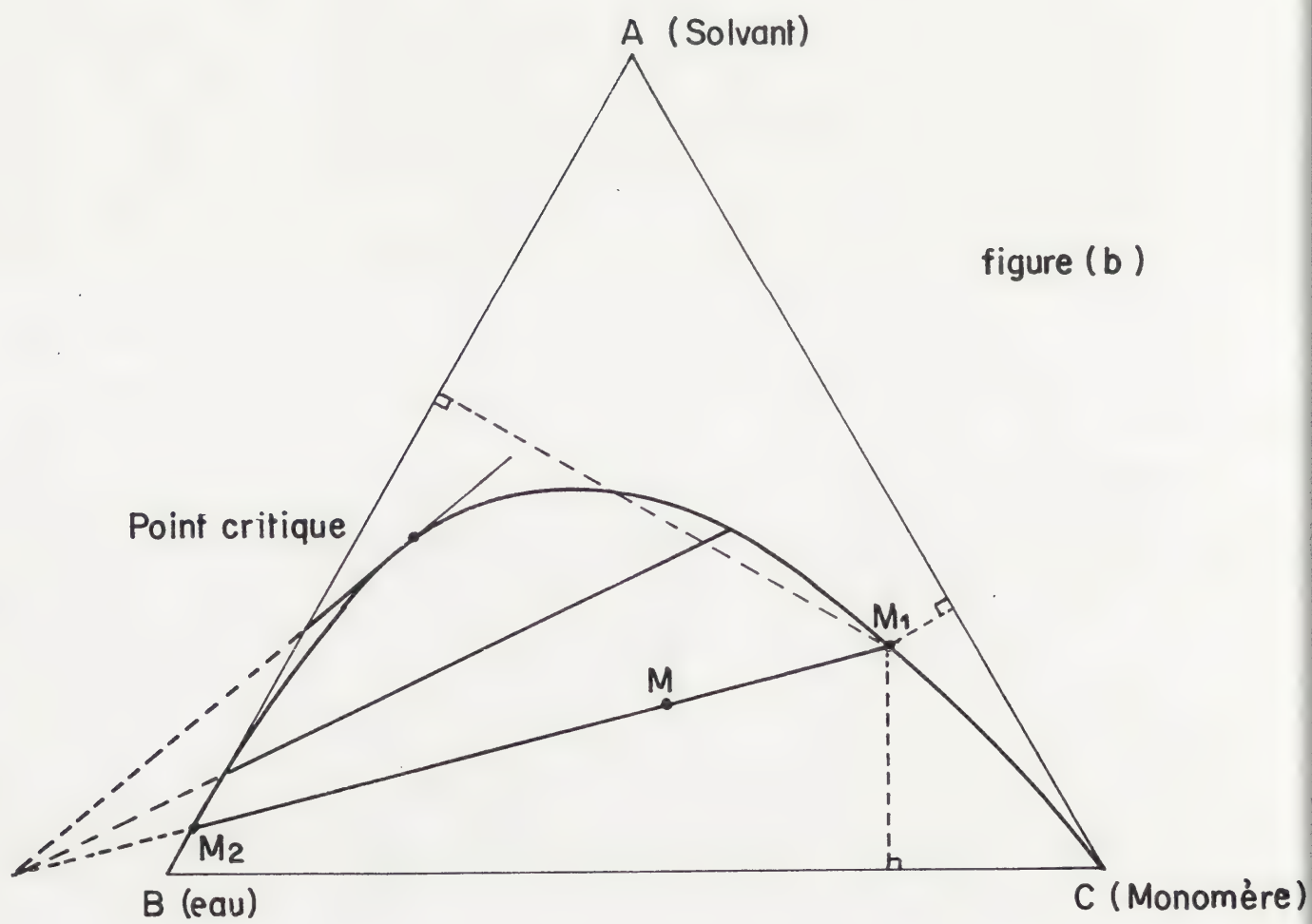


figure (b)





NON-DESTRUCTIVE ANALYSIS OF FUNGUS PIGMENTS IN WORKS OF GRAPHIC ART BY SPECTROSCOPIC TECHNIQUES.-

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INTRODUCTION.

The action of the fungus parasites is one of the biggest causes of deterioration in works of graphic art and papers in general.

Little is known (1) about the kinds of parasitic microorganisms involved in the destructive processes and on the non-destructive analytical techniques for studying the pigments produced by fungi.

The present communication reports the preliminary investigations

(1) - A. Tonolo: Sviluppi delle ricerche microbiologiche per la conservazione della carta - Quaderni del Gabinetto Nazionale delle Stampe, n. 2, 1971.

carried out to investigate the possibility of using visible and U.V. spectroscopic analysis to give information on the nature and on the origin of the pigments formed on works of graphic art.

The special kinds of works of art and papers under examination cannot be analyzed by the usual spectrophotometers without destruction, because the techniques are applicable to solution or transparent media.

The availability of a special spectrophotometer, like the Perkin Elmer 356, will enable us to measure papers, non-transparent materials, etc.

EXPERIMENTAL.

a) Preparation and analysis of samples of old prints containing pigments.

Surfaces covered by various pigments were cut from old prints containing alterations due to the colours produced by fungi.

In order to simplify the analysis of the mixture of pigments, the size of the light beam was made very small, generally 1.5 x 1.5 mm. In this way more homogeneous sections of the pigments could be investigated.

The spectrum of each sample was compared with an undiscoloured surface of the same paper.

In fig. 1 five different spectra are shown representing five series collected from 32 old prints.

b) Preparation and analysis of fungi cultures.

Three different kinds of fungi (Penicillium M16, Fusarium and Cladosporium M12) were each developed in three different culture me

dia, savorand, medium R with cellulose and filter paper treated with Czapek's Dox mineral solution.

Small amounts of mould produced by different fungi were put within two quartz thickness and analysed by spectrophotometer against air.

In the figures 2, 3, 4, are shown the various spectra for each fungus culture.

In the case of the cultures in the paper medium also the spectrum of the pigments produced by the fungus is reported, after scraping the mould, as shown in figures 5, 6, 7.

c) Development and analysis of fungus cultures on coloured paper.

Samples of paper were coloured with various colouring materials such as water colours, pastel, pencil, chalk, etc. and the absorption spectrum has been taken for each sample.

For each colour, four samples were used to develop cultures of Penicillium and Fusarium which had been grown either on Terrano R or on filter paper, until the samples were completely covered with fungus. The spectra of the samples were then taken after scraping off the fungus, using paper of the same type as a reference. In the same way, the spectra were taken of pigments produced by Penicillium and Fusarium on uncoloured paper, as shown in the figures 5, 6, 7, 8. From all of these data, differences in the spectrum of the pigments produced by each culture (Penicillium and Fusarium) were examined attributable to : 1) type of paper sample, 2) type of colouring material, 3) type of growth medium of the fungus.

d) Spectroscopic technique.

The absorption spectra were registered by a Perkin Elmer 356 double beam spectrophotometer in the region of 330 nm - 750 nm, with a tungstene-iodine lamp.

This type of spectrometer is particularly useful for this kind of analysis because of its peculiar characteristics regarding the normal spectrophotometer.

The normal spectrophotometer has an absorption range lower than 1.5 A, which is not enough to measure the absorption of pigments on the prints. Further the position of the samples is too far from the detector, so that the detector collects only a very small fraction of the beam diffused from the sample.

In the Perkin Elmer 356 machine the sample is placed at the surface of the detector, so that the detector collects most of the diffusion beam. Further, the machine has a pair of optical attenuating filters which may be introduced gradually into the optical paths of the beams. By adjusting the filters it is possible to vary the range of absorption.

In our experimental conditions, the amount of light arriving at the detector is very low in any case and consequently the power supply is very high. In order to reduce this effect we enlarge the entrance slit of the monochromator increasing the transmission of the light beam but reducing the resolution. The resolution of 3 nm (against 1 nm under the normal conditions) is still good enough for the purposes of our work.

At the present time the spectra cannot give quantitative values of the absorbance which can be evaluated rigorously, but qualitative results can be compared between the spectra. Because of this, absorbance values are not shown on the figure. The comparison of the absorption intensity of the spectra shown in the same fi-

figure is only approximate.

These difficulties of technique will be overcome by using a special accessory to be delivered by Perkin Elmer Ind. in order to analyze the reflected light from non-transparent materials.

DISCUSSION AND RESULTS.

As mentioned above, Figure 1 shows five representative spectra chosen from about 30 studies of samples of different ages and demonstrating the chromatic changes due to microorganisms. The pigments which have developed naturally in the course of time have absorption maxima usually in the spectral regions 360-380 nm, 420-450 nm and 510-550 nm. These three bands sometimes appear only as shoulders or inflections on the sides of a more intense band. Rarely two other bands at 470-490 nm and 600-650 nm appear which are not shown in the figure. The classification of the series of spectra in Fig. 1 has been performed by comparison with the spectra of pigments which have been developed from fungus cultures in our laboratory as will be described later.

Tonolo ⁽¹⁾ has identified, from microbiological studies three kinds of fungus responsible for the deterioration of paper: Penicillin, Fusarium and Cladosporium. Therefore we have analysed spectroscopically the mould produced by these three fungi and the pigments that they leave on the paper.

Figures 2, 3 and 4 show the absorption spectra of the mould of Penicillin, Fusarium and Cladosporium developed in different culture media: Terreno R, Filter paper, with solution of Czapek's Dox, sabourand.

In each figure there is also shown the spectrum of the pigment produced by the fungus on the same filter paper which is also one of the culture media. It may be seen that the various spectra for each type of fungus are by no means identical.

Figure 2 shows that the pigment produced by Penicillin on filter paper has three bands at about 370, 425 and 510 nm, of which only the last two appear on the mould produced in sabourard, while the mould developed in Terreno R or filter paper shows an absorption rising towards the U.V. without structure.

In figure-3 the pigment left by Fusarium on filter paper, an intense red colour has absorption maximum at about 525 nm with 2 small bands at 360 and 385 nm. However in the mould produced by Fusarium, the absorption rises towards the U.V. (the same as Penicillin and Cladosporium), and reduces the red band of the pigment to a simple shoulder in the curve at about 500 nm.

In Figure 4 the spectrum of the pigment produced by Cladosporium on filter paper, less intense than the previous two, presents two bands at 370 and 430 nm with a wide shoulder at about 600 nm.

The mould however has a spectrum without structure rising towards the U.V.

Overall, comparing figures 2, 3 and 4 with Figure 1, one can see that the spectra of the pigments produced by the fungus on the paper are particularly indicative, much more than the spectra of the mould itself.

The three absorption bands of the pigments naturally produced in paper (360-380, 420-450, 510-550 nm) coincide fairly well with the absorption bands of the pigments produced by the microorganisms chosen according to the research of Tonolo.

To extend the comparison with the pigments taken from books, the spectra of the pigments developed on coloured paper, and subjected to the action of Penicillin and Fusarium as described above in section C were studied.

Figures 5, 6, 7 and 8 show the spectra of pigments developed on paper coloured with water paint, pastels, chalk and pencil, chosen from about 300 spectra taken under various conditions. In each diagram the spectra of the original colour is shown together with the spectra after the action of the fungus. From these, and all of the other spectra, not shown here, several conclusions may be drawn.

The pigments due to Penicillin cannot easily mask the original colour (in Figure 5 it is easy to see the structure of the water paint superimposed on the pigment band due to the Penicillin), while the Fusarium produces a red pigment, so intense as to cover completely the original colour.

In the cases in which the original colour does not have any clear bands, or whose spectrum is absolutely flat (Figures 7 and 8), the bands due to the fungus show up clearly: for Penicillin at 350-360, 420-450 nm (usually the most intense) and 500-550 (often as a shoulder); for Fusarium a very intense band at 520-550 nm and two others rather weaker at about 360 and 400 nm, often only as inflections.

One may note the coincidence of these bands with those of the pigments on filter paper (figures 2 and 3) and with those naturally occurring pigments (figure 1). The tables collect together the data obtained.

From the hundreds of spectra obtained one can see ^{not any} ~~see~~ substantial differences due to the nature of the colouring materials used (waterpaint, chalk, pastels, pencil, charcoal, etc.), to the type of paper used, or to the type of culture medium of the microorganisms (Terreno R or filter paper). No effect has been noticed when the culture was developed in the dark rather than in the light.

In conclusion, one may state that spectroscopic analysis can identify the fungus responsible for the pigmentation and help both in the restoration and in the conservation of works of graphic art.

Using the new accessory for studying reflected light from completely opaque samples a more profound quantitative analysis can furnish more precise data on the destruction of paperwork by fungus.

ACKNOWLEDGEMENT.

We gratefully acknowledge the collaboration of Dr. Ferrajoli and Prof. Govi - of the University of Bologna - in the preparation of the fungus cultures.

FIG. 1 : SERIES OF PIGMENTS NATURALLY GROWN ON BARKS OF GRAPHIC ART.

I SERIES, PIGMENTS SIMILAR TO THOSE DEVELOPED FROM PENICILLIUM.
II SERIES, PIGMENTS SIMILAR TO THOSE DEVELOPED FROM FUSARIUM.
III SERIES, MIXED PIGMENTS.

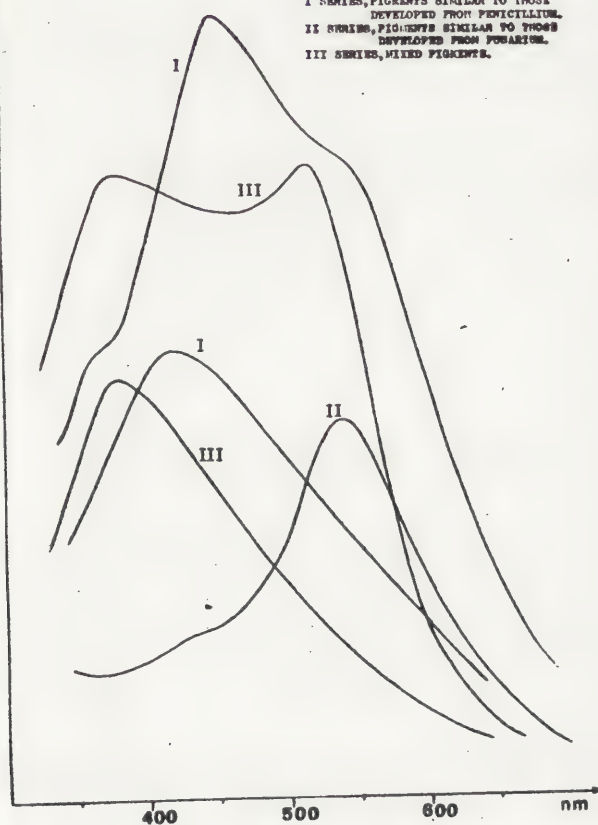


FIG. 2 : SPECTRA OF PENICILLIUM MOULDS DEVELOPED ON DIFFERENT CULTURE MEDIA.

1 - CULTURE MEDIUM R.
2 - FILTER PAPER WITH CLAPPE'S DOX SOLUTION.
3 - SANDOUBAUD.
4 - SPECTRUM OF PIGMENTS DEVELOPED ON FILTER PAPER WITH CLAPPE'S DOX SOLUTION.

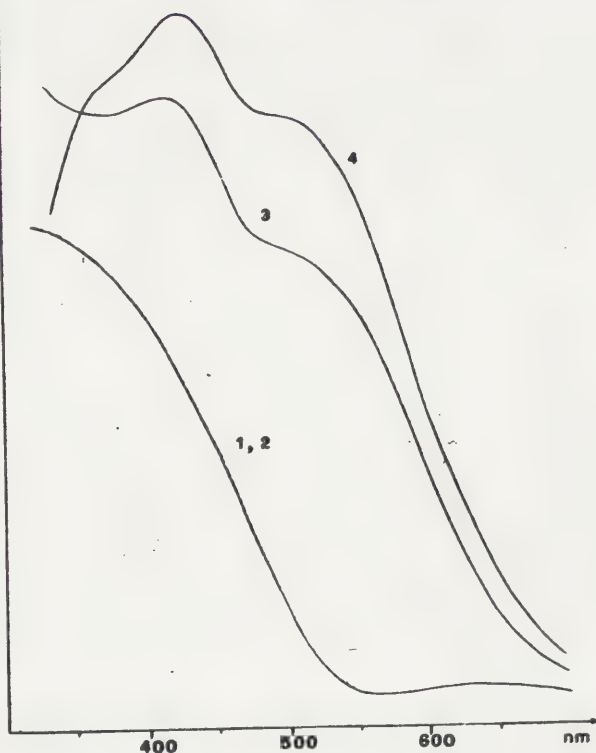


FIG. 4 : SPECTRA OF CLADOSPORIUM MOULDS DEVELOPED ON DIFFERENT CULTURE MEDIA.

1 - CULTURE MEDIUM R.
2 - FILTER PAPER WITH CLAPPE'S DOX SOLUTION.
3 - SANDOUBAUD.
4 - SPECTRUM OF PIGMENTS DEVELOPED ON FILTER PAPER WITH CLAPPE'S DOX SOLUTION.

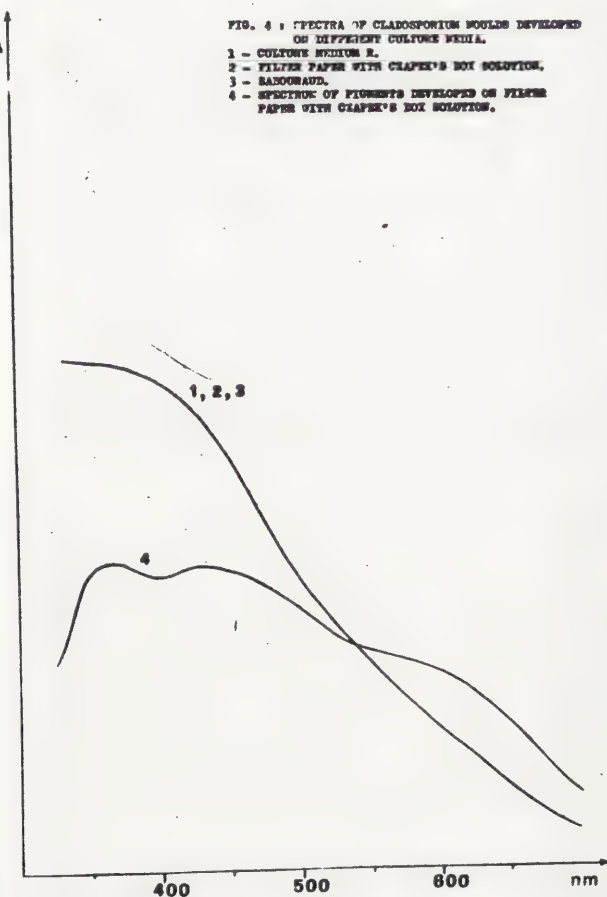


FIG. 3 : SPECTRA OF FUSARIUM MOULDS DEVELOPED ON DIFFERENT CULTURE MEDIA.

1 - CULTURE MEDIUM R.
2 - FILTER PAPER WITH CLAPPE'S DOX SOLUTION.
3 - SANDOUBAUD.
4 - SPECTRUM OF PIGMENTS DEVELOPED ON FILTER PAPER WITH CLAPPE'S DOX SOLUTION.

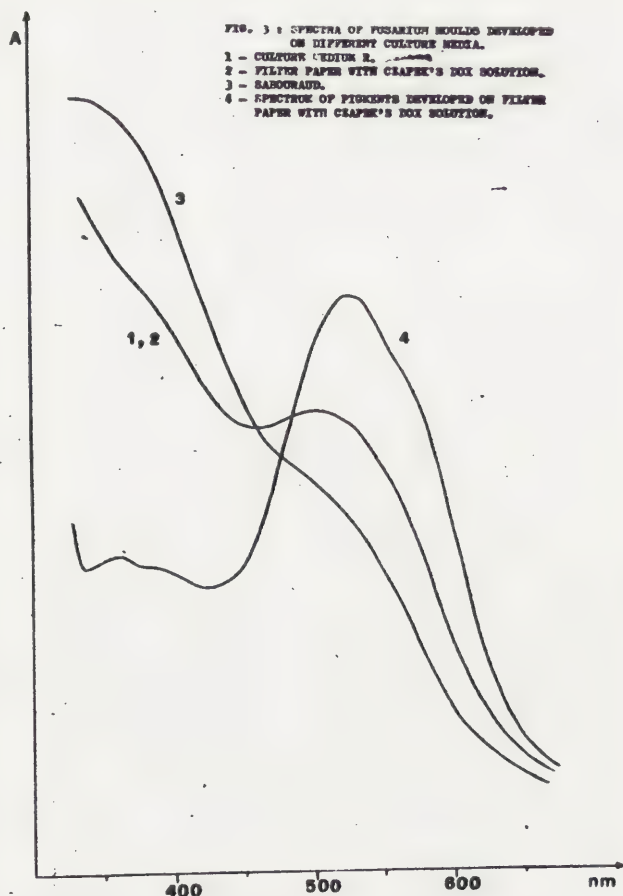


FIG. 5 : PENICILLIUM AND FUSARIUM
ON ACRYLLE.

- 1 - SPECTRUM OF ACRYLLE.
- 2 - SPECTRUM OF PENICILLIUM PIGMENTS
ON ACRYLLE.
- 3 - SPECTRUM OF FUSARIUM PIGMENTS
ON ACRYLLE.

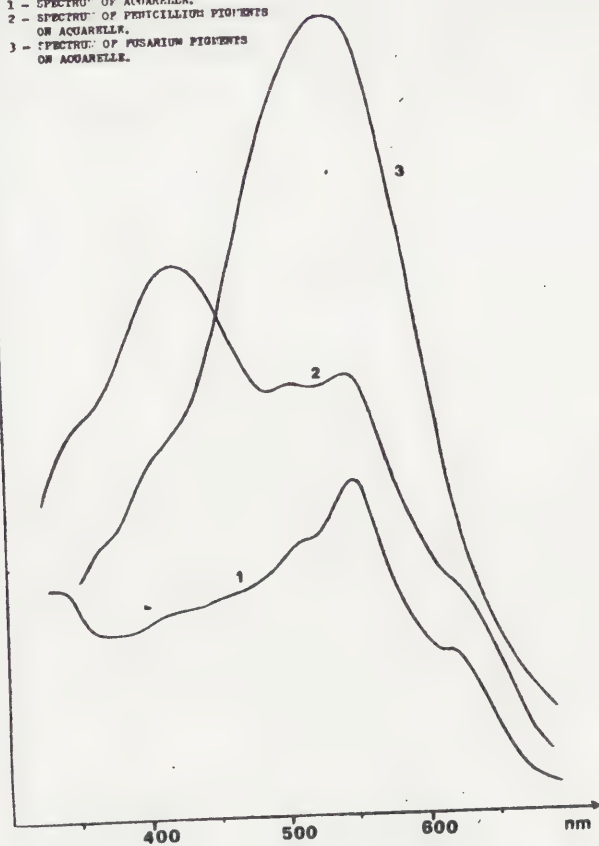


FIG. 6 : PENICILLIUM AND FUSARIUM
ON PASTEL.

- 1 - SPECTRUM OF PASTEL.
- 2 - SPECTRUM OF PENICILLIUM PIGMENTS
ON PASTEL.
- 3 - SPECTRUM OF FUSARIUM PIGMENTS
ON PASTEL.

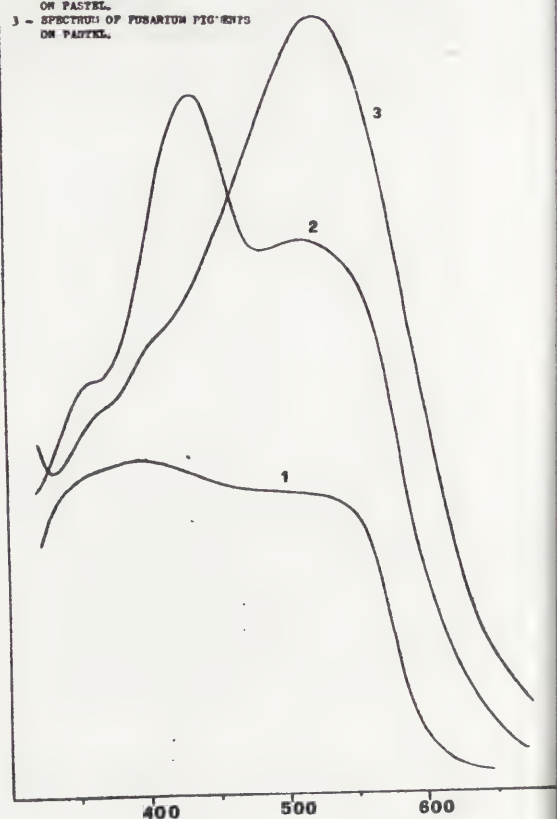


FIG. 7 : PENICILLIUM AND FUSARIUM
ON CHALK.

- 1 - SPECTRUM OF CHALK.
- 2 - SPECTRUM OF PENICILLIUM PIGMENTS
ON CHALK.
- 3 - SPECTRUM OF FUSARIUM PIGMENTS
ON CHALK.

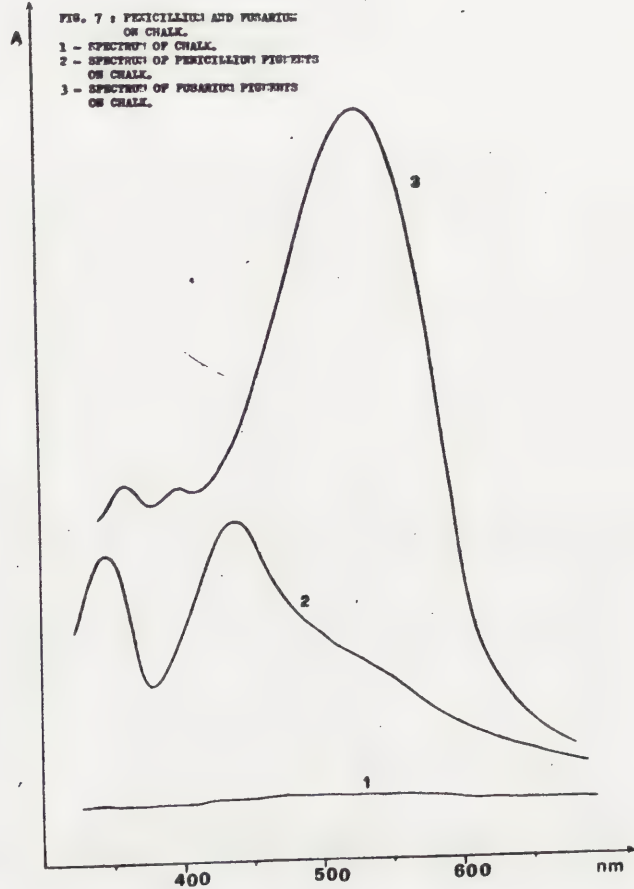
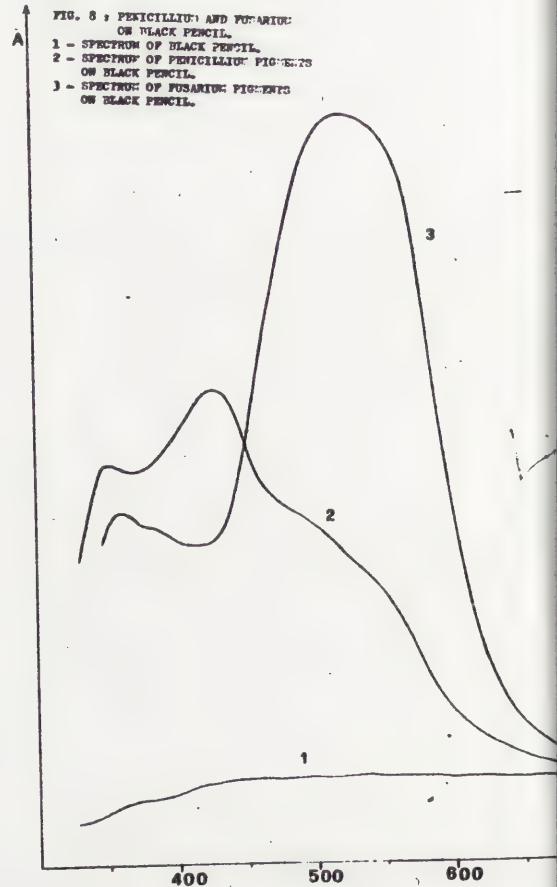


FIG. 8 : PENICILLIUM AND FUSARIUM
ON BLACK PENCIL.

- 1 - SPECTRUM OF BLACK PENCIL.
- 2 - SPECTRUM OF PENICILLIUM PIGMENTS
ON BLACK PENCIL.
- 3 - SPECTRUM OF FUSARIUM PIGMENTS
ON BLACK PENCIL.



T A B L E

Wavelength of Absorption of Microorganism Pigments

Wavelength (nm)	Culture mould	Pigments developed on paper.	Natural pigments on prints (++)		
			I sr.	II sr.	III sr.
360-380	Penicillium Fusarium Cladosporium	Penicillium Fusarium Cladosporium	X	-	X
410-460	Penicillium Cladosporium	Penicillium Cladosporium	X	-	-
470-490	0	0	-	-	X
510-550	Fusarium	Fusarium Penicillium	X	X	-
600-650	0	Penicillium (sometimes)	-	X	X

(++)

I series,

II series,

III series,

pigments similar to those developed from penicillium.
 pigments similar to those developed from fusarium.
 mixed pigments.







ICOM.

COMITE PARA LA CONSERVACION

Madrid, 1972

Algunos problemas sobre la Restauración y Conservación de Libros
y Documentos.

- Laminación con polietileno. Su reversibilidad.
- Laminación en seco, con cinta autoadhesiva.
- Las resinas de polyester, base del papel de un inmediato futuro.

Colaborador:

Vicente Viñas Torner

Jefe del Gabinete Técnico

Servicio Nacional de Restauración de Libros y Documentos.

SOBRE ALGUNOS PROBLEMAS PLANTEADOS EN LA RESTAURACION Y CONSERVACION DE LIBROS Y DOCUMENTOS.

Ante todo, agradezco la amabilidad de Mdme. Flieder - que nos ha permitido disponer de este breve tiempo para presentar - algunos trabajos que actualmente estamos investigando en nuestros - laboratorios.

Por otra parte, ruego disculpen la precipitación y densidad de los temas a tratar pero, desgraciadamente, una deficiencia - de información nos ha impedido aportar a este Congreso otros trabajos con mejor documentación y mayor profundidad científica.

Sin embargo, nuestro espíritu de cooperación nos obliga a presentar algunas de las inquietudes que existen sobre este campo y los resultados que hemos obtenido. Fruto de los trabajos es esta - breve síntesis que exponemos a continuación.

a) Laminación con polietileno: problema de su reversibilidad

No es nuestra intención detenernos a comentar las ventajas o inconvenientes del uso de acetato de celulosa y de polietileno. - En estos momentos es ya un hecho la utilización del polietileno con - resultados altamente satisfactorios.

Sin embargo, hace aproximadamente un año y en una de estas reuniones científicas se suscitó el problema de su reversibilidad. En aquel momento se ignoraba el método de eliminarlo, una vez aplicado sobre el documento y se esperaba que la ciencia aportaría, en un futuro, el disolvente apropiado.

Por entonces, en nuestros laboratorios se utilizaba el - acetato de celulosa y nos resistíamos a aceptar el polietileno precisamente por esta causa -el problema de su eliminación- que sin solucionarlo se quebranta uno de los principales criterios de restauración: "todo producto o materia empleado en restauración debe ser reversible"..

No obstante el polietileno ofrecía unos óptimos resultados y no podía despreciarse como sistema de laminación.

Con esta problemática iniciamos estudios sobre esta materia: proceso de fabricación, características físico-químicas, biológicas, etc. y el resultado fué, a nuestro entender, positivo.

Así pues, supimos que el polietileno es:

- Resina termoplástica derivada del etileno tratado por calor entre 100° C y 200° C y a una presión de 1.000 a 1.500 atmósferas.
- Arde en llama continua.
- Tiene fácil ignición (es decir: inflamable).
- Forma gotas en su combustión.
- Sus vapores tienen reacción neutra y olor semejante al de la parafina.
- Llama luminosa y azul en el centro.
- Densidad de 0,89 a 0,98 gramos mililitro.
- Fusión entre 110° C y 175° C.
- Índice de refracción entre 1,51 y 1,54.
- Resistencia a la tracción entre 80 y 200 Kg/cm².
- Resistencia a la rotura por alargamiento entre 200 y 750 %.
- Resistencia a la flexión entre 100-120 kg/cm².
- etc, etc., y, hasta el momento, no digerible por los insectos.

En nuestro proceso de laminación se aplica una temperatura de 115° C y durante 30 a 35 segundos.

Dos procesos hemos seguido en los estudios de su reversibilidad:

1º con benceno

2º mezcla de xileno y tolueno al 50%

Ambos procesos -debemos advertirlo- deben realizarse por personal especializado y con las debidas medidas de seguridad y prudencia, especialmente con el empleo del benceno, pues sabido es su alto poder tóxico y su punto de ebullición (80° C). No obstante, to

mando las precauciones necesarias, la eliminación del polietileno es sencilla y no debe de implicar riesgo alguno, como a continuación detallamos:

- 1º) Todo el proceso debe de realizarse en una cámara extractora de gases.
- 2º) Colocar una cubeta con el disolvente (benceno o xileno y tolueno), sobre una placa eléctrica. Nunca sobre llama.
- 3º) Introducir el documento laminado sobre una hoja de teflón.
- 4º) Elevar la temperatura de la placa eléctrica hasta alcanzar 80ºC si se utiliza benceno y 125ºC si se emplea xileno y tolueno. (En ambos casos la temperatura indicada es el - punto de ebullición).
- 5º) Mantener brevemente esta temperatura (unos segundos) - hasta observar el desprendimiento del papel tissue. La - operación se puede favorecer con ayuda de pinzas, espátulas y pincel.
- 6º) Una vez eliminado el papel tissue se puede eliminar el exceso de polietileno con ayuda de pincel y espátula.
- 7º) Si una vez extraído el documento del baño se aprecian - restos de polietileno en forma de veladura blanquecina, - se puede quitar con un simple algodón seco o ligeramente humedecido con el mismo disolvente de la cubeta.
- 8º) Una vez volatizado el disolvente queda algo rígido el documento. Entonces debe humedecerse, colocándolo, final-- mente, en la prensa hasta su total desecación y planchado.

Insisto en los riesgos de toxicidad o de inflamación pero debo hacer constar que en ninguna de nuestras experiencias ha ocurrido accidente alguno.

b) Laminación en seco.

Se entiende por laminación en seco, la no utilización de ningún elemento que proporcione calor o humedad. En el método que proponemos se trata simplemente de la aplicación de una película - autoadhesiva sobre el documento a laminar. Este método viene a reg

resolver el problema de aquellos documentos que no permiten la laminación por calor-presión o la laminación con adhesivos acuosos.

En el mercado existen, ciertamente, diferentes películas autoadhesivas. Algunas de ellas totalmente rechazables por los efectos secundarios, nocivos al documento sobre el que se aplican. - Otras, que no pueden introducirse en el campo de la laminación porque no permiten obtener, por xerocopia, reproducciones del documento laminado.

Estudiado el comportamiento de estas cintas autoadhesivas que se venden en el mercado, observamos que existe una de ellas que casi podemos decir que se ajusta a las condiciones ideales. Esta cinta, a la que no tengo otro remedio que citar por su nombre comercial, es la "Scotch Magic" de la firma Minnesota.

Puestos al habla con su Delegación en Madrid y aunque - no supieron darnos una documentación precisa sobre sus componentes se prestaron a facilitar el material necesario para nuestros estudios. Resultado: diacetato de celulosa como elemento soporte y derivado de polivinilo el adhesivo.

La casa comercial se prestó también a proporcionarnos tres modelos diferentes, con la particularidad de no estar cortado en cintas sino en rollos de 1 metro de ancho.

Con láminas de dimensiones variables experimentamos sobre diversos documentos, especialmente sobre periódicos. El resultado es satisfactorio, teniendo que resaltar su alta transparencia y buen comportamiento ante diferentes ensayos de resistencia mecánica.

El único problema se plantea en el momento de su aplicación sobre el documento por su propiedad electrostática. Dificultad que puede reducirse humedeciendo el documento en acetona, o mejor aún, colocando el documento en una rejilla a la que se ha aplicado un sistema de aspiración de aire.

Una vez superpuesta la lámina autoadhesiva debe pasar-

se un rodillo para eliminar las posibles burbujas.

Su reversibilidad es sencilla. El disolvente del acetato es acetona sola o con acetato de amilo. Para el adhesivo puede emplearse el éter como elemento disolvente.

c) Las resinas del polyester: Base del papel de un inmediato futuro.

Actualmente, una de nuestras mayores inquietudes, surgida al calor de nuestra convivencia con Mr. Barrow, es la permanencia y durabilidad del papel, (entiendo por permanencia la retención de las propiedades de uso significativo y funcional y por durabilidad el factor que representa el mantenimiento de la calidad).

Conscientes de la responsabilidad que supone la postergación del documento escrito y la fragilidad de los papeles actuales, algunos investigadores han aportado sustanciales variantes en la fabricación, llegando a garantizar un papel, con una permanencia y durabilidad de 100 años. Sin embargo, aunque estas aportaciones son altamente positivas, únicamente, deben significar un leve respiro en el esfuerzo por lograr un tipo de soportes más estables que no modifiquen la funcionabilidad del papel actual.

Nadie mejor que archiveros y bibliotecarios saben de las dificultades para que el material bibliográfico y documental de hoy puedan ser utilizado a partir de unas pocas generaciones.

Es lamentable tener que admitir que, a pesar de los avances técnicos, la exigencia de una mayor producción papelera es la principal causa de que un papel recién manufacturado, posea, entre sus características, una durabilidad menor que el papel del siglo XV, obtenido de forma artesano y con precarios medios. No es nada arriesgado asegurar, que, dentro de tan solo cien años, un documento medieval podrá seguir siendo consultado con casi idénticas precauciones que las actuales, mientras que el papel de nuestros días, difícilmente habrá podido superar este tiempo.

La introducción de los plásticos en el campo de la con

servación y restauración, en general, ha supuesto el hallazgo de una materia altamente satisfactoria, tanto por su facilidad de aplicación como por los resultados obtenidos. En los materiales de archivo y biblioteca se emplean las resinas plásticas, tanto para fijar sustancias solubles como en consolidación, encuadernación y especialmente en laminación.

El que estas materias se usen actualmente con tanta intensidad y en escala progresiva es, sin lugar a dudas, el mejor aval para su mejor aceptación, no como elemento de aplicación "a posteriori" - sino para su empleo "a priori". Es decir, en la propia industria papelera.

La aparición en el mercado de algunos papeles de dibujo obtenidos a base de resinas de poliéster, su fabricación industrializada en Finlandia, la edición en Japón de un libro de papel sintético, son en mi opinión, la esperanzadora realidad de un tipo de soporte para la escritura, cuyas ventajas superen los inconvenientes industriales, comerciales y funcionales.

Las dificultades que pueden entrañar el cambio de materias se asemejan a las que fueron superadas cuando el pergamino cedió su prioridad al papel "de tina" y más tarde, a las transformaciones que los molinos papeleros tuvieron que admitir hasta convertirse en fabricas de papel "continuo".

Costes de fabricación, adiestramiento de personal, introducción en el mercado etc., forman parte de un interesante capítulo que en nuestro caso no despreciamos pero que rebasa esta primera - intención centrada, exclusivamente, en la búsqueda de un tipo de soporte para la escritura que supere las cualidades actuales.

El déficit de la madera es cada día mayor y por el contrario la generalización de las materias plásticas permite intuir precios competitivos, máxime si tenemos presente la cualidad de poder reutilizar cierto tipo de resinas.

Entre las principales características de las resinas de pbllyester, aplicables a la industria papelera destacamos:

- Aspecto físico muy parecido al papel (tacto, color, opacidad, brillo, etc.)
- Excelente comportamiento al uso continuo.
- Posibilidad de utilizar la mayoría de los medios más comunes de escritura (lápiz, bolígrafo, cinta de máquina...)
- Elevada resistencia mecánica. En las pruebas de torsión, tracción, plegado, estallido, etc., ha dado incluso un 100% de mayor rendimiento.
- Buena resistencia química. Hidrófugo.
- Alta resistencia a los ataques biológicos.

A pesar de disponer de datos más concretos es todavía prematuro hacer otras afirmaciones. Actualmente estamos realizando en nuestros laboratorios estudios encaminados a investigar esta materia con el fin de aportar datos que permitan mejorar la calidad de este papel sintético. Entre sus características negativas debemos citar:

- Reducido poder de absorción, impidiendo la retención de algunas tintas actuales, salvo el empleo de fijativos o el uso de tintas especiales que ya existen en el mercado (tinta china - TT, Pelikan).
- El problema que plantea su resistencia a la destrucción, salvo el empleo de sustancias químicas o de combustión, suponiendo que no se hayan incluido elementos ignífugos en su manufactura.

Es de comprender que nuestra intención no es masificar el papel sintético sino el de reducirlo, de momento, al uso de cuanto material bibliográfico y documental sea merecedor de ser conservado y también en los casos de la reproducción de documentos más frágiles.

Convencidos de esta necesidad hemos establecido un programa de investigación en el que cooperan, indistintamente, expertos en la industria papelera y en el campo de los plásticos. Agradeciendo cualquier colaboración o sugerencia.

Toda esta comunicación, solo ha pretendido dar a conocer algunas de las inquietudes y esfuerzos planteados en el recién creado Servicio Nacional de Restauración de Libros y Documentos, de Madrid.

Vicente Viñas

Jefe del Gabinete Técnico.







Report to the ICOM Committee for Conservation
Madrid, October 1972

The treatment of swamp degraded wood
by freeze-drying

W.R. Ambrose

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INTRODUCTION

The general problems associated with the treatment of degraded wood from water environments, and reviews of progress in this field, have been the subject of previous detailed reports to ICOM committees (Muhlethaler 1963, 1965, Tomashevich 1965). In addition there have been recent publications in which various treatments are reviewed and suggestions for modification, improvement, and new techniques are suggested (Stamm 1970, Christensen 1970).

The purpose of this paper will be to set out some details of the application of freeze-drying in the treatment of swamp-degraded hardwood artefacts. Our choice of freeze drying, initially on an experimental scale, was prompted by the impression that the massive bulking procedures, such as those with hot alum solutions or heavy molecular weight polyethylene glycols, were often producing unsatisfactory results. It was also evident that though the various solution exchange methods, such as alcohol-ether-resin, were satisfactory on a small scale, they could not be applied safely or economically for large quantities of wood. We were also hesitant about the use of water displacement by resins which were later to have *in situ* polymerisation.

Though in no way comparable in size or quantity with the many tons of timber recovered as sunken ships in European sites, the amount of archaeologically recovered wood to be treated from sites in the highlands of Papua New Guinea was sufficient to warrant a search for a more ideal drying treatment.

The problems associated with the heavier molecular weight grades of polyethylene glycol, i.e. their inability to diffuse into some timber (Tarkow *et al.* 1966), and the loss of fine surface texture or detail in wood soaked for months in their hot solutions, all argued against the adoption of the total bulking method with polyethylene glycol. Christensen (1970) has fully set out the experimental evidence which demonstrates these difficulties.

Stamm (1970) has found it possible to stabilise degraded wood by simply applying coatings of polyethylene glycol 1000 in increasing concentrations up to a 30% solution and then gradually drying the specimen in decreasing humidity from 90% RH down to 30% RH. Figure 1 shows the amount of polyethylene glycol which would remain in the sample after drying wood degraded to various degrees and saturated with different concentrations of polyethylene glycol in water.

Most of the Papua New Guinea swamp wood has lost between 50% to 80% of its weight on drying, while a few pieces have lost 85% of their initial wet weight. A 30% aqueous solution of polyethylene glycol in this wood, as suggested by Stamm, would represent a final dry concentration of polyethylene glycol ranging between 45% to 170% of the weight of wood substance in the sample. At these concentrations the effect of a 30% solution will be that of a bulking agent, though not comparable to the total bulking of a 100% solution..

The amount of bulking agent present in the treated sample is proportional to the wood's accessible voids which will progressively increase as degradation proceeds. If the bulking agent is a relatively hygroscopic lower molecular weight polyethylene glycol, there will be problems in storing the treated object in a humidity sufficiently low to avoid weeping of the bulking agent which has the unfortunate effect of producing a dark moist colour in the treated samples. We have tried to avoid these two effects by reducing the soaking solution to 10% for a degraded test sample and allowing it to dry slowly in air. The results were not satisfactory since the wood suffered distortion and shrinkage cracks.

In any bulking system the agent itself must be stable under normal museum storage conditions. If low humidity storage is available (less than 40% RH) then bulking with polyethylene glycol 1000 would achieve stabilisation in the timber. For large scale operations on wood which has not suffered extreme degradation, such as the stabilisation of the

large wooden ship Vasa, there is probably no better alternative than the present treatment with solutions of polyethylene glycol 1000.

Where the objects are more wieldy, or are more degraded methods other than massive bulking may commend themselves and research in this direction is desirable.

Our experimentation with freeze-drying of the Papua New Guinea swamp wood collection was prompted by a wish to avoid the heavy bulking which had become almost standard practice in conservation laboratories up to recent times. The Papua New Guinea collection is to be returned to the humid tropical conditions of Port Moresby, where low humidity storage is yet to be established in the Museum storage areas. Our success in applying freeze-drying to the collection encourages us to continue the refinement of the process in anticipation of a much larger collection being recovered and requiring treatment later this year. One major advantage of this non-bulking freeze-drying system is the wider range of storage humidities that can be tolerated by the treated wood.

Freeze-drying (Lyophilisation)

The fundamental aspects of freeze drying have been outlined by Rey and Rowe (1964). The main conditions required for freeze-drying to occur are fairly simple. Firstly the water vapour pressure above the ice surface must have a steep negative gradient so that randomly escaping water molecules tend to be removed from the ice face. This is usually achieved through lowering the total atmospheric pressure above the ice to a vacuum of 1 torr or less. It is also possible to create the water vapour gradient at atmospheric pressure by using air, dried to a very low water vapour pressure and circulated across the subliming ice. The second main requirement is for heat to be conveyed to the ice surface to replace the latent heat of sublimation which is lost in converting the solid ice to vapour. The latent

heat of sublimation is equal to the heat that would be necessary to melt the solid ice and convert the liquid into its vapour phase (Rowe 1964:142). The manner in which these requirements are met in large scale commercial plants, processing many tons of foodstuffs a day, is largely an engineering problem. Nevertheless, the feasibility of using freeze-drying for large scale processing of sound but perishable materials has been proven over many years.

Degraded wood is in a rather special category since, unlike for example foodstuffs or animal tissue, to a certain extent only a remnant of the original structure is present. The water in the wood sample is in fact serving two roles; firstly as a false structural component by virtue of its bulking action, and secondly in a weak chemical fashion by neutralising the hydrolysed, and depolymerised, cellulose components. The direct removal of water has the familiar but alarming effect of destroying the wood sample with shrinkage and distortion. The high surface tension of water is capable of overwhelming the relaxed structure of degraded wood and is mainly responsible for the drying damage.

However, if it was simply a problem of removing the water without it being able to exert its surface tension force within the wood sample, then its removal by sublimation from its ice phase should be the simplest and most effective method. Results of direct freeze drying have not proved satisfactory and checking or splitting of dried samples is the usual problem. Physical rupture of degraded wood occurs when freezing of water-saturated samples is attempted and before any sublimation of the ice has begun. Even when ice rupture is avoided, by using intermediate tertiary butanol as the sublimating agent, checking and splitting of the dried sample occurs (Rosenqvist 1959:65). This is probably due to the weakly bonded water within the sample. Removing the bulk water by normal sublimation of ice does not remove the absorbed water on the enormous surface area of the sample (Ray 1964:38).

The high affinity for moisture of wood treated by tertiary butanol sublimation, ensures that atmospheric moisture will be very quickly absorbed when the object is removed from the vacuum.

As wood components hydrolise, and it degrades, the water which is present at saturation level is able to neutralise any potential random weak bonding between the increasing number of terminal polar groups in the sample. The degraded cellulose is not free to reorientate itself into a different structural configuration, for the presence of water at saturation level can satisfy any hydroxyl ends which might otherwise combine in drying conditions. Sound wood which has been allowed to dry does not regain its former volume when its former moisture conditions are reestablished (Tamm 1944:454). Similarly, the failure of degraded wood to swell, once having dried out is possibly also partly due to an hysteresis effect caused by the bonding of pairs of cellulose hydroxyls which, on being drawn together on drying, are not available as adsorption sites when moisture is reintroduced to the sample. As degradation proceeds the voids will increase and only be prevented from collapsing inwards by the presence of water. Freeze drying of such a sample may prevent the major collapse of voids but the presence of broken cellulose links with terminal hydroxyl groups may, in the presence of small amounts of moisture, tend to draw together and shrink the sample.

Therefore it appears that though the great bulk of water can be removed successfully by sublimation from a degraded sample, the presence of bound surface water will produce noticeable damage. This damage will not be of the familiar type, when water is simply evaporated from a sample, and which produces a predominantly radial shrinkage. The damage will appear as a more random pattern of shrinkage cracks caused by the more equalised contraction of internal surface areas affected by bound water.

The presence of a non-evaporating material which can mix with the bound surface water and neutralise its contracting effect on the sample, would help to avoid post-drying shrinkage. Liquid grades of polyethylene glycol can achieve this effect. Polyethylene glycols' terminal hydroxyl groups can form weak bonds with water or hydrolised cellulose and so counter the tensional collapse of the degraded wood components when free water is removed by sublimation. Adjacent hydrolised units of the cellulose are probably neutralised by the polyethylene glycol at low concentrations.

Polyethylene glycol 400 (Union Carbide, Carbowax 400) has a vapour pressure at 100°C of 9.0×10^{-5} mm Hg. If a solution of polyethylene glycol 400 and water is frozen and suitable conditions are created for the sublimation of ice, the polyethylene glycol will remain while the ice will be preferentially removed. A 10% solution of polyethylene glycol in water has a freezing point of about -1°C. Undiluted polyethylene glycol 400 freezes at between 4 and 8°C. Therefore an object saturated with a 10% solution at the beginning of sublimation would yield water vapour while the polyethylene glycol remains as a porous waxy support for the drying structure until a temperature above 4°C is reached. Above this temperature the polyethylene glycol would presumably migrate as a liquid until it had reached a concentration equilibrium by diffusion in the sample. On freezing a 10% solution of polyethylene glycol 400 yields a mass of small crystals. The expansion of ice is reduced by the shrinking of the polyethylene glycol. A simple test by freezing a 10% solution of polyethylene glycol 400 in a paper cup shows that no damage to the vessel occurs on freezing. Water frozen in the same way ruptures the paper cup. In tests on the swamp woods the same reduction in freeze damage is observed.

Calculation of the correct concentration of polyethylene glycol 400 to be introduced into the sample is important. Generally it appears that the more degraded the sample the less percentage of polyethylene glycol is necessary per unit

volume of water in the undried specimen. This can be appreciated by reference to Fig. 1 where the percentage weight of polyethylene glycol in a dried sample is plotted against the percentage loss of water from the sample for various initial concentrations of polyethylene glycol. In a badly degraded sample, for example one which loses more than 80% of its wet weight on drying from a solution of 10% polyethylene glycol, the remaining polyethylene glycol will account for about 45% or more of the sample's dry weight. Because of its fluidity, and hygroscopicity in high humidities, any excess of polyethylene 400 in the sample greater than that necessary to act as bound surface water will create problems by making the sample appear darker and damp. Conversely, in a sample which is only moderately degraded, for example one which loses only 60% or less of its weight on drying from a solution of 10% polyethylene glycol, the remaining polyethylene glycol will account for only 17% or less of the sample's dry weight. This amount appears to be too small in some cases and slight surface checking of some sounder samples has been noticed.

Since either an excess or a deficiency of polyethylene glycol 400 in a degraded sample can produce a poor result, it is necessary to have some idea of the ratio of water to wood substance in the object to be treated so that the concentration of the soaking solution can be adjusted accordingly. In practice a final polyethylene glycol 400 concentration of about 20% in these treated swamp woods appears to produce the most satisfactory results.

Field Treatment of degraded swamp wood

Immediately following its excavation the wood samples ~~are~~ *is* washed to remove any extraneous matter. Any excess surface water is allowed to dry off before a 50% solution of polyethylene glycol 400 is applied. The wood being recovered from excavations in the Papua New Guinea highlands is in the form of digging sticks and long-bladed spades up to three

metres long. The wood, liberally coated with the polyethylene glycol solution, is inserted into long sleeves of polythene and sealed at both ends. The polyethylene glycol in the package retards drying because of its hygroscopicity and also limits the growth of fungus on the wood. Provided the polythene packages are well sealed the wood can remain in storage for two or three months without perceptable drying.

C¹⁴ Samples

Many wood samples were previously collected for carbon ¹⁴C dating during the excavation and were returned to the laboratory without polyethylene glycol treatment. The purpose of this was to guard against any possible contamination the polyethylene glycol may have had on the C¹⁴ activity of the sample. Preliminary tests were carried out in the radiocarbon laboratory at the Australian National University to determine what effect the polyethylene glycol may have on the radiocarbon activity of the treated wood. The polyethylene glycol 400 we are using does not contain C¹⁴ (ANU-354). Therefore, the presence of polyethylene glycol in a wood sample might be expected to increase the sample's apparent age if any remained fixed in the wood following the radiocarbon dating washing pretreatment. A sample of wood was divided, one half being soaked in 10% polyethylene glycol 400, the other half being untreated. Normal pretreatment washing procedures were carried out on both samples before their C¹⁴ activity was determined. The activity of the polyethylene glycol treated sample (ANU 427) is indistinguishable from the untreated sample (ANU 428). This result confirms that no difficulty of C¹⁴ contamination is likely to be encountered in using polyethylene glycol for the field treatment of all samples.

Soaking in Polyethylene glycol 400 solutions

On arrival at the laboratory the wood, each piece with its identifying metal tag, is immersed in a 5%-12% solution of polyethylene glycol plus a small amount of water soluble

sodium salicylanilide tetrahydrate as a fungicide. As mentioned above, sounder wood requires a greater concentration of polyethylene glycol in the solution to achieve a final satisfactory dried result than does greatly degraded wood. This problem of the best relative concentrations requires some investigation but, simply as a rough working basis, it is possible to categorise the condition of degraded wood in terms of its compressive strength or, preferably, on the water loss on drying of small samples of the larger specimen. The optimum solution concentration of polyethylene glycol should lie somewhere between 5% for extremely degraded wood (>75% weight loss) to 8%-10% for the medium strength samples (60-75% weight loss) to 12% for relatively undegraded samples (<60% weight loss). This results in a final concentration in the dry wood of between 15% to 25% which we judge from past results to be the optimum range. Preliminary tests have shown that it is possible to check the degrade in a less arbitrary fashion by using photodensitometer readings on X-radiographs. Woody material is more transparent than water to X-rays. By using low kV X-rays, (around 10 to 15 kV), the difference between saturated sound wood and saturated degraded wood of the same species is apparent. This difference, where sound saturated wood is more transparent to X-rays than degraded saturated wood, is due to the higher percentage of water in the degraded sample. Though the expense involved would not warrant the use of this technique on a large scale, it could be used to give a quantitative basis to the tactile compression tests on the majority of samples. We intend to examine this question further when the swamp wood from this year's excavations has arrived.

The time the wood needs to remain in its solution of polyethylene glycol is difficult to calculate. The rate of polyethylene glycol diffusion in wood is no doubt governed by the normal diffusion parameters of concentration gradient, depth of penetration, density of the wood and temperature. However no simple method of measuring the depth of penetration

in a wood sample appears to be available. We have, simply by observation of experimental pieces, adopted the practice of soaking all the wood for between six and twelve months, depending on its size and state of degrade. Soaking is carried out at normal air temperature.

Freezing

Up to seven kilograms of soaked wood is assembled in a foam polyurethane trough in a bed of crushed CO_2 (-79°C). When the wood is thoroughly frozen it is tightly wrapped in a layer of aluminium foil which is intended to distribute heat to the object at a later stage when sublimation has begun. Several 2-3 cm gashes are torn in the foil to facilitate the escape of vapour from the package under vacuum.

The solidly frozen, aluminium-wrapped objects are loaded on a copper tray which in turn rests upon a copper heating coil within the vacuum chamber. A thermocouple is inserted to the centre of the largest diameter object in a 1 mm hole drilled for this purpose. A few drops of water seal the thermocouple in place. Another thermocouple is taped to the surface of the object. The vacuum chamber is closed and pumping down commences. The thermocouple temperatures, heating coil temperature, vacuum pressure, and cold trap condenser temperature are all monitored.

Vacuum sublimation

A record of vacuum and temperatures is kept for the drying of each chamber load of wood. A typical record is shown in Fig. 2. It can be seen that the pressure drops within the chamber until the sublimation rate increases with the increasing ice temperature. When the subliming vapour is being withdrawn from the chamber at the same rate as it is being produced at the ice surface, an equilibrium pressure is achieved which appears as a plateau in the chart. The heat of the coil is kept at about 40°C , being controlled by

a small pump and heating element in a reservoir outside the chamber. Should the pressure rise above 1.0 torr the heating coil temperature can be quickly lowered.

By the time the object is placed in the chamber and pumping has started, the core temperature has risen to about -60°C or more and continues to rise slowly.

Between the main vacuum pump and the chamber a mechanically refrigerated condenser is kept at between -40 to -45°C . The vapour pressure of ice at this temperature is about .095 torr. The minimum pressure achieved in the system is .3 torr so that the condenser traps most of the vapour passing over it. A single stage gas ballast pump rated at 300 litres per minute, which can rapidly evacuate the chamber at the outset, ensures that no melting of the objects can occur before a good vacuum is achieved.

The wood is considered to be dry when the vacuum increases and the core temperature rises above freezing point. Pumping is continued until the core temperature reaches air temperature. This is to ensure that moisture will not condense on the inside of the object when air is admitted to the chamber. It also ensures that all pockets of ice are sublimed away completely. Otherwise their presence in the sample would lead to patches of moisture in the object when it is exposed to warm air.

The processing of one load of timber varies in time according to the surface area of the load. Thus a multitude of small items will be dried in a shorter time than a single piece of timber of equivalent weight. Because the rate of sublimation decreases as the thickness of the dried surface shell increases, it becomes more difficult (a), to supply heat to the subliming ice core because of the insulating properties of the dried shell and (b), to remove the vapour produced at the core surface because of the impeding effect of the dry shell. Rowe (1964:155) states that the time to sublime a given thickness of frozen material varies according to the square of the thickness.

Modified systems

Presently two modified systems to increase the sublimation rate of the thicker wood samples are being examined.

1. When the pressure inside the chamber is brought to ordinary air pressure, heat is more readily conducted through the dry shell to the ice core of the frozen object. Unfortunately the vapour produced at the surface cannot readily escape and eventually saturation water vapour pressure would be reached and liquid water would form at the interface. However by a cyclic process of raising and lowering the air pressure, it is possible to admit heat to the system and maintain the necessary steep moisture gradient away from the ice surface. If the air being introduced into the chamber during a cycle is already fully dried to a dew point below that of the ice surface, it will help in maintaining the moisture gradient away from the ice.

2. Freeze drying has been achieved at atmospheric pressure (Rowe 1964:164). The production, in recent years, of reliable large capacity air drying equipment based on a molecular sieve dessicant makes it possible to consider using this for freeze drying our wood materials. The idea is that the sample would have the same pretreatment as it would for vacuum drying. The frozen object is exposed to an atmosphere of flowing air dried to a dew point of about -70°C . The air readily heats the ice surface while its very low water vapour pressure (equivalent to about 4.7×10^{-3} torr) provides the gradient necessary to remove the vapour from the drying shell. Whether the conditions for continued sublimation can be achieved for relatively thick specimens remains to be tested. It will probably be necessary to control the heat flow to the surface so that it does not induce sublimation at a faster rate than the diffusion of the vapour away from the surface.

Results so far

All the wood from previous excavations has now been treated by vacuum freeze drying. Some of the severely degraded samples are too fragile to handle without the loss of fragments from the easily abraded surface. It will be necessary to impregnate these samples with some consolidating resin if they are to be safe for normal museum handling. Tests with low concentrations of Bedacryl 122X in toluene or epoxy resin thinned to a low concentration in acetone are promising but so far there is no programme of consolidation for the fragile samples. As mentioned previously, the polyethylene glycol which remains in a badly degraded sample is in excess of the requirements of wood's internal surface area if the initial soaking concentration is too high. An 8% polyethylene glycol soaking concentration for these badly degraded samples has produced in the dry specimen, a darker colouring than in less degraded samples. This is probably because the more than 25% of polyethylene glycol in the dried sample is greatly in excess of the internal surface area requirements. One virtue of the system is that these samples can be resoaked in lower concentration solutions and again be processed through freeze drying to achieve a lower final concentration.

The majority of wood has responded well to the 8%-10% soaking solutions and suggests that the optimum final concentrations of polyethylene glycol 400 lies between 15% to 25% by weight of the dried wood.

The least degraded wood has in some cases shown some surface checking which is probably caused by a lack of sufficient polyethylene glycol to preclude condensed water stresses in the depolymerised cellulose structures. An 8% soaking concentration would leave a 10% final concentration of polyethylene glycol in the dried sample in cases of only slightly degraded wood. This is probably too little to

satisfy the internal surface area requirements of these samples. A soaking concentration of polyethylene glycol 400 up to 12% or 15% should overcome this difficulty by achieving a concentration in the dried specimen of around 20%.

Unlike wood treated by total bulking methods, the freeze dried samples from Papua New Guinea do not appear to be discoloured or impregnated with plastics materials. The wood is light and porous and the finest tooling marks, made by stone axes, are well preserved. Many of the samples came to us as adventitious finds, as a consequence of drainage operations in the Wahgi Valley swamps. Where no field treatment was given, and the objects were allowed to partially dry out before they reached us, the damage they suffered was irreparable. The role of quick systematic field treatment is crucially important for as is well known, drying damage in swamp degraded wood is quite irreversible.

Details of Equipment

The equipment (fig. 3) is basically the same as that previously reported (Ambrose 1970) except that an air drying device is now available for a cyclic input of dried air, and for experimental work with air-flow sublimation.

- A. The vacuum chamber is a welded steel cylinder 30 cm. in diameter and in two sections of 1.5 metres. The two sections are fitted with flanges and end plates 1.6 cm thick and coupled with normal 'O' ring vacuum seals.
- B. A single stage air ballast vacuum pump, with a capacity of 300 litres per minute and achieving a pressure of .01 torr, is operated throughout the drying of a batch.
- C. A smaller vacuum pump, of 80 litres per minute, is used as a standby to operate if the condenser needs emptying of its ice load.

- D. The condenser is a small vacuum chamber with copper cooling coils entering from the end plate. Up to 4 kg of ice can be trapped before it needs to be emptied. The temperature on the coil is kept at about -40°C . The coil is supplied by alcohol of this temperature from a cooling reservoir E.
- E. The alcohol reservoir is fitted with a small pump to drive the refrigerated alcohol through the coils of the condenser.
- F. A mechanical refrigerator which cools the reservoir to -40°C to -45°C .
- G. The temperature of the load within the chamber is registered by thermocouples connected to a potentiometer.
- H. Heat is supplied to the load by circulating hot water up to 40°C in copper tubes which form a support for the frozen samples. The hot water is pumped through the system by a thermostatically controlled heater and pump mounted in a small reservoir at H.
- I. Valves are situated between the small pump, C, and the chamber, a solenoid valve is between the chamber and the condenser to isolate the load in case of power failure, another is in line between the main pump and the condenser.

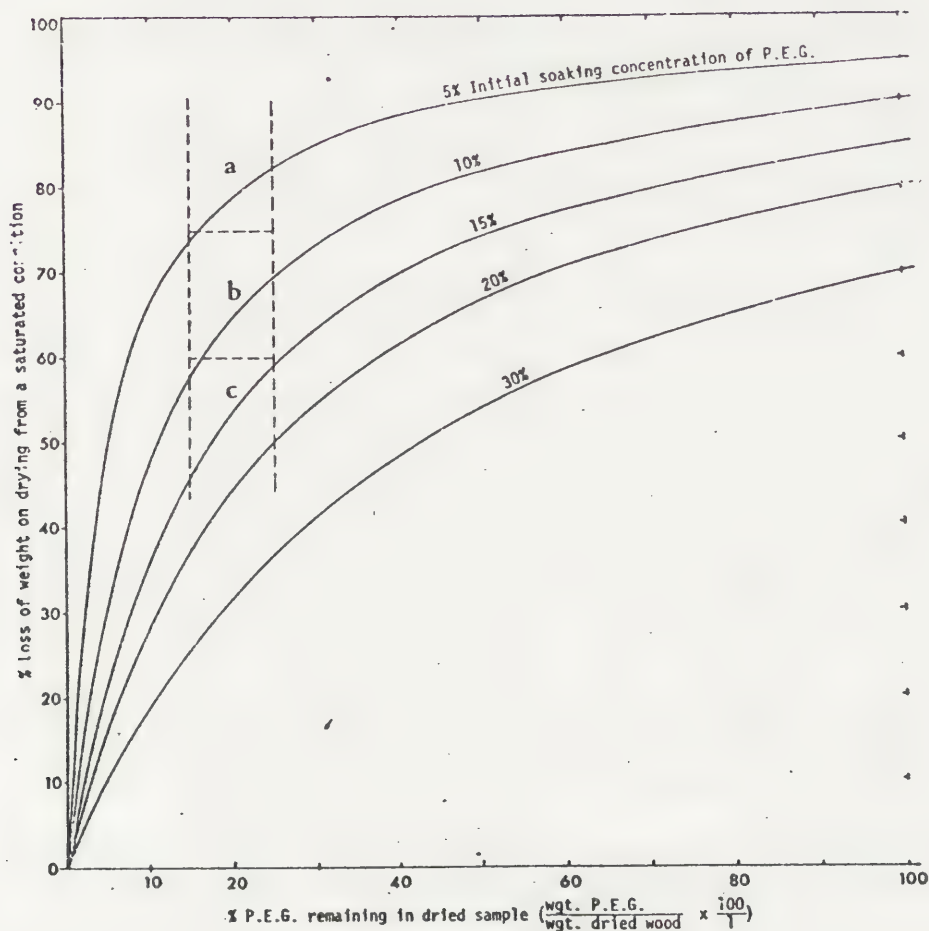


Figure 1. Showing the percentage retention of polyethylene glycol in samples dried from a range of soaking concentrations of polyethylene glycol between 5% and 30%. The best results in practice have been where samples have retained about 20% of polyethylene glycol in the dried wood, this optimum zone is indicated by a dashed line; (a) highly degraded with more than 75% of weight loss on drying requires an approximately 5% soaking solution; (b) moderately degraded with between 60% to 75% weight loss gave the best results with a soaking solution between 8% and 10%; (c) the least degraded, with less than 60% weight loss requires a 12% to 15% initial soaking solution to produce the best results.

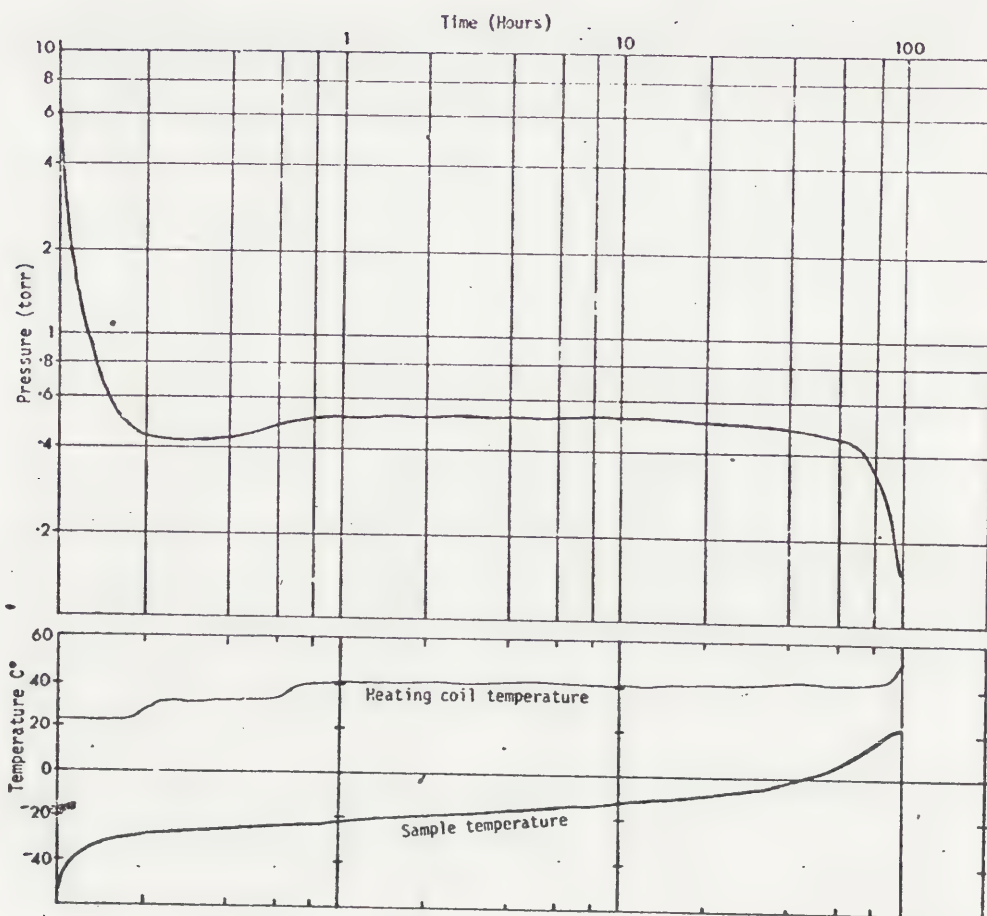


Figure 2. Typical plot of temperature and vacuum for a load of frozen wood.

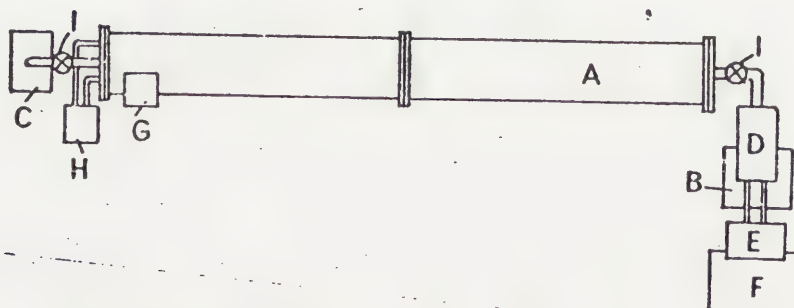


Figure 3. Diagrammatic representation of the freeze-drying equipment (plan view).

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Papers on the conservation and technology
of wood

ICOM Committee on conservation
(sub-committee - furniture)

Madrid, October 1972

N.S. Brommelle, J.A. Darrah, A.J. Moncrieff
Victoria and Albert Museum, London
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INTRODUCTION

The first reports in this series (in 1963 and 1965) dealt with the general features of wood decay in interior woodwork including furniture. A summary was given of the principles of furniture restoration. This material was published in "Problems of Conservation in Museums" (ICOM 1969). A further report (1967) included a review of relevant literature from 1960 in wood technology; this was later published in Studies in Conservation by Anne Moncrieff. This review was brought up to date in the next report in 1969 together with expanded sections dealing with wood-moisture relations, impregnation and moisture barriers. The present survey by Anne Moncrieff and Jo Darrah brings the literature up to March 1972. These reviews are expanded bibliographies; the items are chosen to provide source material for further study. They lie somewhere between bibliographies, abstracts and short digests.

Replies to a questionnaire on conservation methods for wooden objects, sent to museums and private restorers were summarised in the 1967 report. There is no point in sending out further questionnaires at present. Included also on the 1967 report was a list of publications received from Forest Products organisations in consequence of requests from Sub-Committee members. The organisations have not followed these gifts with more recent publications and further circulars might be profitably sent out.

It has not been possible to proceed with two of the projects proposed at the 1969 meeting in Amsterdam. These were firstly a study of the behaviour of experimental constructions of basic furniture under cycles of atmospheric relative humidity variation which was postponed until new premises were available; they will soon be started: secondly a study of the technical history of furniture construction beginning with certain limited periods in particular countries. In the second study it was hoped to assist the stylistic specialist by systematising the sequence of technical innovations in a similar manner to the fruitful collaboration between technical and art-historical specialists in painting. This was a false analogy. In painting technical methods develop with the successive discovery or introduction of new materials, advancing and being advanced by artistic evolution. Furniture construction has fewer degrees of freedom. It is geared to the basic properties of wood (until recent times, at least) which is anisotropic both in its strength and in its dimensional changes with moisture content. Moreover technical evolution, which has been reasonably well charted by the style experts, and is not of great complexity, is ordinarily bound up with function and the development of social customs and style; assignment to a particular period is generally dependent on an experienced appraisal of these factors. Changes in style from the 17th century onwards have been more rapid and detailed than changes in basic constructional methods and provide a better chronological guide. Even so the study of the gross structure of constructional change has scope for refinement beyond the ordinary detection of reproduction work, which relies on such things as the presence of anachronisms in tool marks and in such features as screws and nails. This refinement cannot be done by a research programme, but by gradually amassing and analysing the results of examinations from as many sources as possible, using a common system of recording, and making as much distinction as can reasonably be accomplished between construction and style. To this end, a start has been made to provide an examination schedule which might be developed for general use for the systematic description of both construction and deterioration, to be useful for conservation as well as for the collection of historical material. This will require a comprehensive vocabulary of technical terms in several languages, so that each technical

feature will have one agreed description, with diagrams if necessary. Proposals for developing this project and enlisting co-operation will be made at the Madrid meeting.

In the survey that follows many of the references included will appear to be only remotely if at all connected with the technical study and conservation of furniture. A large proportion of the published literature, even on furniture, concerns itself with such materials as laminated woods and production line methods of manufacture. However it must be noted that museums (including the Victoria and Albert) are already collecting material of the so called "Art Deco" period of 1925 onwards, and Miss Darrah notes, in the section on wood identification that there is an urgent need to collect information on the wide range of tropical and other woods now being imported, and their dates of introduction. The section on wood identification and its recent literature is a reminder that museum records are not normally very complete nor accurate in this respect, and the above proposals for systematic examination should aim to modify this aspect, with the wide adoption of the use of accepted standard keys and more detailed analysis where possible.

A reference was made in the last report (for the Amsterdam meeting 1969) to the use of very soft X rays and to ultrasonic methods for detecting flaws and imperfections, and it was suggested at the meeting that a possible method should be sought, not only for detecting cracks in the interior of furniture members and beneath veneers but also of detecting furniture which is potentially at risk in adverse atmospheric conditions. It appears from the recent literature that the ultrasonic methods are not yet sufficiently advanced to be considered. There is now, however, the possibility from American developments in holography, of detecting hidden cracks, or regions of local stress by combining two holographs taken at brief successive intervals with minute changes in moisture content, to produce interference fringes with a pattern related to stress variations.

Relevant references to the expanding literature on dendrochronology are reviewed in this report. This method which is now being successfully applied in suitable cases to dating the panels of some northern European paintings has not yet been used on furniture, though a study of furniture of the "oak period" will doubtless be undertaken eventually.

Occasional outbreaks occur of metallic corrosion in museum objects in storage or on display that appear to be traceable to emanations from wood and associated materials in the vicinity. These occur too rarely for close study to have been made, and they are sometimes difficult to investigate. A particularly baffling example is being studied at the moment at the British Museum. A brief review of the current literature on this subject is included here. The effect of light, mentioned in previous reports, is most noticeable in the variously coloured and dyed woods of 18th century marquetry furniture but very general even though subtle changes are occurring under present museum conditions where curatorship has been generally much slacker than in the fields of textiles and paintings. It is a common experience to see patches of sunlight, perhaps of 10,000 lux on furniture in museums and country house out-stations. A review is included of literature on the effect of light on colour. Some additional research in the museum field is clearly needed covering the range of furniture woods normally encountered, on the magnitude of the changes and the effect of spectral composition, to draw the attention of curators to this matter.

As in previous reports the literature on fungal and insect attack is reviewed, from the point of view of chemical treatments other than fumigation it would be interesting to know what methods are now being used in museums, Since the

questionnaire reported upon in 1967 was circulated; and in the light of the recent attitude towards persistent and potentially dangerous insecticides.

There is still no reasonably comprehensive book on the restoration of furniture as it is practised by a museum restorer conscious of the object both as an example of applied art and as an authentic historical document. The higher grade of museum furniture restorer will have learnt his craft by developing from a cabinet-maker to a restorer, and it can be argued that the practice cannot be learnt from a book. There are, however, numerous museum technicians who can effectively carry out the more elementary tasks of restoration and who are likely to try to go further than their skill and knowledge warrants. A suitable treatise could save much damage. A review is given in this report of a number of recent books, which, however do not quite fulfil the present need. There is also almost no occasional literature on specific treatments of difficult problems, comparable with those on the treatment of wood panel paintings, as for example those illustrating the recent publication by R D Buck on the rheology of wood panel painting supports.

Reference was made, in the previous report to Buck's earlier work on the subject of his more recent article and its relevance to the deterioration of furniture. Apart from normal (and abnormal) wear and tear it receives as a functional object, much of the deterioration of furniture consists in the warping, shrinking and cracking of ~~timbers~~ and the accompanying damage to veneers. The problem which Buck considers is that of wood panel paintings with paint on one side only providing an unbalanced effect consisting firstly of a moisture barrier on one side leading to asymmetrical moisture gradients in conditions of varying relative humidity and secondly to a mechanical constraint which prevents the swelling and shrinkage of the wood on one side and constrains it on the other. This situation, in which the ultimate results is compression-shrinkage on the free side and possible tension-set on the other, a permanent condition as a consequence of plastic flow, must have analogues in the veneered panels of furniture. These effects would be superposed on the general shrinkage of free members as a consequence of the lower average RH in museums compared with that resulting from the original air seasoning. The effect of cross battening in wood panel paintings is well-known and is manifest in furniture, from its mode of construction. A loosely framed panel is free to move, and usually shrinks without damage. On the other hand a panel held in end clamps running across the grain, or one constrained by heavy moulding as for example a panel in a box-like construction, will crack and distort. The furniture problem involving in a compound way the spring and dash-pot concept described by Buck and complicated here and there by the dead space within closed box constructions turns into a question of magnitudes which have not been determined. In particular, if the furniture gallery is humidified in winter but not controlled in summer what is the consequence in terms of compression-shrinkage etc., of rapid cycles of relative humidity in the higher humidity range of the summer months?

In the previous review, Miss Moncrieff considered the possibility of using moisture barriers on chosen surfaces in furniture in an analogous way to their use on wood panel paintings. Lacking the basic knowledge outlined above on the magnitude of the effects, this cannot be safely done at present. Her comprehensive review of moisture barriers in the previous report has been brought up to date in the present contribution. Some formidable work is being done on the principles of transmission of moisture through coatings, which may eventually help to explain some of the confusing results. More detailed analysis is being made of the separate but interacting roles of diffusion and sorption in the process of permeation. We have not yet quite absorbed this work with regard to the conservation problems, where we are interested in

(a) transient rather than equilibrium conditions (b) a substrate with its own moisture content and diffusion characteristics. As a practical point, the fluorocarbon films emerge as possible rivals to Saran (polyvinylidene chloride - acrylonitrile copolymer) with, additionally durability with respect of weathering and light.

Miss Moncrieff has also brought up to date her previous review of methods of stabilisation by impregnation, and the conclusion still remains that stabilisation by bulk and graft polymerisation in situ is not at present feasible for museum objects.

N S BROMMELLE

A timber tree is a merchant adventurer, -
you shall never know what he is worth till
he be dead.

John Evelyn - "Sylva"

Wood Identification

The identification of wood in museum objects often seems to be ignored or at best done by guesswork. Anyone with a basic knowledge of wood anatomy, possessing a good lens or a microscope and a sharp razor can identify the commonly occurring species of their own area. The physical qualities of wood, dimensional stability, decay resistance and appearance are all important in its preservation and a knowledge of the species can help the conservator.

The presence of a particular species of timber can sometimes help to date an object or pinpoint the area in which it was made. A knowledge of the original appearance of timber can assist the art historian to visualize the original appearance of an object, particularly furniture whose dowdy brown appearance today may belie the intention of its maker or designer. The damage visible today in what appears to be a well constructed piece of furniture may be due to the use of timber totally unsuitable for the purpose eg. an unstable carcass wood under beautifully laid veneer, long since torn to pieces by the movement of its support.

Visitors to museums are often interested to know what a wood is, especially the more exotic woods of cabinetwork, but do not always find identification on the label.

The most comprehensive system of identification of both softwoods and hardwoods is contained in publications of the Forest Products Research Laboratory [F.P.R.L.] (UK) (1,2,3,4). These have been available for a number of years. Identification is by means of characters present in the wood and for ease of use the information can be transferred to cards. Over nine hundred species of world timbers are covered. Two leaflets describe the method of identification of timbers and how to prepare material for microscopical examination (5,6).

Three papers (7,8,9) describe techniques for cutting wood sections. Vynkier (7) describes a method for preparing brittle wood by embedding the material in methyl methacrylate. Bramhall and McLaughlan (8) use a thin metal-cutting saw which will cut sections to 100 μ m and avoids the damage which is caused by a microtome. Hyland (9) describes the adaption of a jeweller's fine circular saw for cutting sections of woody stems.

Wood can be identified by macerating the tissue and examining individual fibres. This allows very small splinters to be removed from objects from which it would otherwise be unwise or impossible to obtain samples. Butler (10) describes the preparation of macerated fibres and the use of the polarizing microscope for identification.

A more specialised technique, of importance to archaeologists and paleobotanists, is that of charcoal identification. Wood, when burnt in a reducing atmosphere, is converted to pure carbon. Being totally resistant to biological breakdown it is frequently preserved on archaeological sites and may give evidence of ancient culture practices. The anatomical features remain intact. Koeppen (11) describes the preparation of samples for use with an incident light microscope or a good hand lens. He also tells how to prepare a reference collection of charcoal samples.

Scheiber (12) discusses the nomenclature of timbers. Many timbers have several commercial names and some of these incorrectly suggest their

relationship with timbers of known quality so this is a matter of some importance. Scheiber lists one hundred English and German names commonly used in the trade that are consistently misleading. He gives their original, botanical and standardized names.

Taras and Kukachka (13) describe a simple identification method for distinguishing hickory and pecan, which have different properties and qualities but are often confused.

Young and Watson (14) discuss softwood structure and the identification of conifers. They coded and analysed by computer the data for one hundred and thirteen species in forty-two genera of conifers. Their results show that conifers fall into two major groups, Pinaceae and others, distinguished by salient anatomical characters. Most taxonomical groupings are supported by the analytical data but the Cupressaceae fall into two widely separate groups of the northern and southern hemispheres.

Several books have appeared recently which contain specimens or photographs of commercial timbers. These books are perhaps more useful for finding a timber with specific qualities or colour rather than for identifying an unknown but they are well produced and unlike a collection of wood samples give all the relevant facts as well. "Hough's Encyclopaedia of American Woods" (15) makes one wish that this could be extended to cover European and other woods. It is worth its high price. Each of the six volumes produced so far consists of two parts. The first, a text, covers the geographical range and distribution of the tree; the history of its discovery; uses; past and present commercial importance; physical appearance; tables of strength, weight, etc. The second part contains wood sections double mounted on white card in a ring binder. Transverse, radial and tangential thin sections of each wood are mounted on one page. These are beautifully prepared and show, as no photograph can, the colour, grain and figure of the wood specimen. Twenty five species are covered in each volume, giving a present total of one hundred and fifty species.

A less ambitious volume, "What wood is that? A manual of wood identification" (16) covers the common commercial timbers used in Europe. The text gives a description of the tree and wood and contains identification keys. A fold out panel at the front of the book holds forty wood samples of veneer thickness. Some important timbers are ignored while other, less important varieties are described.

Three volumes of "World Timbers" (17) have now been published. Volume I describes twenty-six European and fifty-three African species, Volume II, thirty North American and thirty South American and Volume III, forty-three Asian, twenty-two Australian and eight New Zealand species. The text covers the distribution and supplies of the timber, a general description, technical properties, seasoning and movement, strength and bending properties, durability and preservative treatment, uses and working and finishing properties. One to three colour photographs of each timber are reproduced in their natural size and show the wood in its most frequently used form, i.e. quarter-cut; flat-cut; rotary cut and burr.

A further two volumes have been added to Bergmann's, "Encyclopaedia of Timbers" (18) making five in all. A revised edition of "Commercial Timbers of the World" (19) adds nine new timbers to the two hundred and fifty-two described in the 1965 edition. The book has a chapter on wood

structure and identification and another on timber for the architect and engineer. The rest of the book contains descriptions of the individual timbers which in all cases are rather superficial. Photomicrographs of transverse sections are given for some species.

The "Centre Technique du Bois" has produced a paper (20) on indigenous and exotic timbers in use in France. Eighty-four species are described; common and scientific names, provenance, description, density, hardness, workability, mechanical and technical properties, durability and uses. Six short papers (21,22,23,24,25,26) describe fir, spruce, scots pine, oaks, beech and poplars; their taxonomy and pseudonyms, geographical distribution of the tree, structure of wood and characteristics for microscopical identification with photographs of transverse, radial and tangential sections; physical and mechanical properties; technical details and uses. A further publication (27) contains tables for the macroscopic determination of twenty-one timbers commonly found in France. This is produced for the layman and gives only the French name for the timber.

Menon (28) describes the structure and identification of fifty-two indigenous Malayan timbers derived from three hundred and seventy five species. This handbook is illustrated and contains keys. Tuset and Duran (29) describe the key to macroscopic characters of the commercial timbers of Uruguay.

"Woodworking Industry", continues its series "Know your Timber" (30) each month. It has now (March 1972) covered two hundred and twelve timbers with a general description and a photograph (black and white).

"Wood" maintains a similar series "World Timbers" (31) from material provided by F.P.R.L. (UK). This contains a general description and a colour photograph (natural size). Over one hundred species have now been described and earlier numbers have been produced in book form.

The Canadian Forestry Service is building up a system for "Hardwood Identification by Computer" (32). This is intended as a service for the public. Up to the date of reporting, 1968, the basic data for five hundred species, obtained from the F.P.R.L.(UK) "Identification of Hardwoods" (3) and other sources have been transferred to magnetic tape for computer retrieval.

The U.S. Department of Agriculture Forestry Service has produced a useful paper on the "Properties of imported tropical woods" (33). It describes more than one hundred tropical genera and generic groups which are, or could be, imported into the United States and was published to answer some of the many queries which they receive. The paper contains the information available at the time of publication. This provides botanical and common names; principal growth areas: description of the wood; properties; seasoning and uses.

A symposium report from Germany (34) on the "Properties and utilization of tropical wood" discusses the great increase in wood exports in some areas in the last few years. The technical data for many timbers are scattered and the information must be collated and published together as in the previous paper. The report discusses the uses of timbers, the availability of technical information and evaluation of their properties.

As time goes on many of the "new" timbers will appear in museum objects, a point which must be remembered when papers on tropical woods are

considered. Some of the large number of "new" species imported into the developed countries, particularly of western Europe, since 1945, are already commonplace in furniture and turnery.

This Museum hopes at some future date to compile a list of timbers imported into the U.K. during the twentieth century and of their first importation. If this is left too late the information may well become as difficult to obtain as that of the eighteenth and nineteenth century imports. Latham Bryan's book (35) covers timber from a historical point of view and contains much valuable information about early imports. The importation of new timbers is likely to continue as shown by Brazier (36) who suggests several new woods, giving their trade names; botanical names; geographical origin, density, etc.

Richardson (37) believes that there will be no shortage of tropical hardwoods in this century. He lists all those in current use in the U.K. and gives their main uses.

Bootle (38) describes "Furniture Timbers of New South Wales". The paper contains a list of many species used in the modern furniture industry and gives their characteristics.

Two earlier papers from the F.P.R.L. (UK) (39,40) survey the timbers and board materials used in the furniture industry (1966) and timbers used in the musical instruments industry (1956). The Canadian Forest Service have also produced a paper on the "Wood for Musical Instruments" (1964) (41) referring to species growing in Canada.

Structure of Wood

Wood structure and anatomy is covered to a greater or lesser degree by the general botanical textbooks. A few books exist which deal exclusively with wood. Jane's "The Structure of Wood" (42) has recently been revised as has the F.P.R.L. (U.K.) "Growth and Structure of Wood" (43), and Panshin and de Zeeuw's "Textbook of Wood Technology", Volume I (44). A new edition of Giordano's "Wood Technology" has appeared (45).

In "Bibliography on the anatomy of woods", by Araujo (46) the first section deals with Brazilian papers (220 titles) and the second with the rest of the world (1403 titles).

Greguss', "Wood Anatomy of European dicotyledous trees and shrubs", (47) has been revised, as has Freud's "Microscopy of wood and paper" (48).

A paper by Bamber (49) discusses the trouble which can arise from the use of sapwood in manufacture. He describes the difference between heartwood and sapwood, their development, the determination of the boundary between them, and their relative strength, durability and utilization. Chemical tests are given which can differentiate between sapwood and heartwood.

Detailed work on the crystals present in many tropical hardwoods is described by Jongebloed and Jutte (50). These crystals are often used as an identification characteristic and are of importance to woodworkers as they can damage tools and cause difficulty during working. The authors describe the improved results obtained by using X-ray microscopy compared with those of the light microscope. Ultra-violet and polarized light microscopy fall between the two. There is a series of photographs of different types of crystals found in wood.

Von Pechman (51) describes two useful staining techniques for wood. The first uses Astra-blue to produce a contrast between normal cells and those which are poorly lignified, and to stain living parenchyma and fungal hyphae. Tension wood of the convolute type is clearly differentiated from normal cells. Astra-blue is particularly good for detecting fungal mycelium in cell walls, etc. The second stain, the fluorochrome, Acridin Orange, differentiates cells of the second type of tension wood. The first stages of wood decay are shown well by this stain.

Frey-Wyssling (52) discusses the ultrastructure of wood in relation to its anisotropy and longitudinal shrinkage.

Reaction Wood

Reaction wood, i.e., tension wood and compression wood, is now described in books on wood structure and botanical text books, e.g. White (53). The dangers of using timber containing these defects are well understood. Much detailed work continues to be done on the subject but is not relevant to this review. Much of the information has been obtained using the electron microscope (see next section).

Electron Microscopes

The use of the electron microscope, and especially the scanning electron microscope (S.E.M.) to study wood structure and anatomy has increased greatly in the last few years. Papers are reviewed here which show the general breadth of research covered using the techniques, and those which are relevant to museum work. The transmission electron microscope (T.E.M.) requires a replica to be made of the sample, which is then destroyed. This method has been used to study the ultrastructure of Southern Yellow Pine wood (54), with the aim of differentiating anatomically between the ten species and two varieties studied. The paper contains two hundred and fifty electronmicrographs of cell wall structure etc.

A second paper (55) describes the use of the technique to study the penetration and decomposition of tracheid walls of Pinus sylvestris by a fungus and discusses the action of cell wall breakdown by fungal enzymes.

The T.E.M. and an electron probe analyser were used to study the impregnation of pine wood with aqueous solutions of metal compounds by different methods (56). The electron probe analyser proved a useful instrument for detecting and analysing metal compounds in the cell walls.

Macerated wood fibres from five woods of varying hardness were examined under the T.E.M. (57). The efficacy of three different maceration processes are evaluated.

For the examination of wood surfaces, anatomy, deterioration and weathering the scanning electron microscope (S.E.M.) has proved useful. Samples may be examined without pretreatment apart from drying and in some cases shadowing. Its greatest advantage is the depth of focus which is several hundred times that of the T.E.M. or the light microscope which means that a photograph gives effective information on three dimensional objects. Its resolving power can be ten times that of the optical light microscope (to 150°A). The instrument has been available for a decade but in 1968 its use for the study of plant material was being described (58).

A review of research in the field of wood science using the S.E.M. was published in 1970 (59). In 1972 a book "Three-dimensional structure of wood, a S.E.M. study", (60) shows just how far the use of this microscope has added to the knowledge of wood structure.

Wood anatomy (61) and wood anatomy and decay (62) were studied and photographs presented to illustrate the value of the S.E.M. in this type of work. More material is presented in a paper (63) on wood structure and degradation. Weathered wood can be examined without any alteration and has therefore received much attention. Borgnin (64) has evaluated the use of the S.E.M. for studying changes in the structure and ultrastructure of weathered wood exposed to natural weathering for up to a thousand years in buildings in Norway.

He describes the deterioration of the wood and its structural breakdown and concludes that the S.E.M. is ideal for this type of work. He discusses the same work under the title "Why wood is durable", (65). Hydrolysis and photochemical reactions are of little significance. The gray surface layer of weathered wood protects the lower layers by absorbing and reflecting chemically active ultraviolet light and visible light. Oxidative and hydrolytic breakdown are very slow indeed. Protected wood, nine hundred years old, shows almost no deterioration whereas on the weathered side the surface has broken down. This he believes to be due mainly to thermal and hygroscopic movements in the exposed surface. The middle lamella of the cell wall appears to be the weakest point. He concludes that wood under certain conditions is extremely durable.

Other work deals with weathering of wood and the fungi which cause gray stains. (66,67).

Ultrasonic Detection of Wood Defects

The use of ultrasonics to reveal structural defects or decay in timber has been studied for several years. The theory behind the technique is that ultra-high frequency sound waves pass through material at different velocities according to the density of the material. Changes in density, flaws, etc., are recorded. The development of this technique could possibly yield another useful tool to museum conservators for the detection and study of the development of cracks and flaws in wood sculpture, furniture, etc. The technique does not seem to have reached this stage. A note (68) reports on the press release from the National Research Council of Canada on the use of high-frequency sound waves for the detection of defects in wood. The author of the note unhappily concludes that an experienced woodcutter in Malaysia or Ceylon could do the same with his ear! McDonald et al. (69) discuss the locating of defects in lumber by ultrasonics. Parrott (70) describes its use to find decay in timber. Breeze and Milberg (71) also describe its use on wood having internal decay and predict from their measurements the log crushing strength. At the same time direct measurements were made of the extent of soft decay and crushing strength again predicted. Both methods of prediction were found to be equivalent when compared with actual crushing strength.

Borovikov et al. (72) describe the influence of density and moisture content on the rate of propagation of ultra-sound waves in Scots Pine.

A new approach to the problem of detecting structural defects leading to cracking in wooden objects is foreshadowed by the technique of producing

interference fringes with successive holograms, taken before, and after a minute change in moisture content (73).

Dendrochronology

The science of dendrochronology has been used for many years by botanists, foresters, archaeologists etc., but has only quite recently become of interest in the museum. Originally the age of wood and trees was calculated by counting the number of annual growth rings present. Later the width of the annual growth rings was measured and the results for different trees were compared. Climatic conditions in a geographical area affect the majority of trees of a given species similarly so that a particularly good or bad year will affect the amount and type of growth leading to differences in the width of rings in each tree. These form a pattern which when plotted allow trees to be matched. With a given area continuous chronologies can be worked out going back for as many years as samples are available (up to 6000-7000 B.C.). A single chronology cannot be used over a wide area but tree-ring chronologies are now available for many parts of Europe, North America, and elsewhere. Archaeological excavations have provided much material and have extended chronologies by many years. Conversely, available chronologies have helped to date excavations.

Trees of temperate zones which show well developed annual growth rings are especially suitable for this work. In Europe oak, pine and fir are the most useful timbers for this work because they have extremely well developed and easily measured growth rings. They are moreover the most commonly used timbers in construction work and the best preserved both on excavation sites and in peat bogs. Other species have been studied both in Europe and in other areas of the world. Unfortunately trees in tropical areas do not all possess growth rings and if they do they may not be annual and are no use for dating purposes.

Matching and analysis is frequently done by computer today, though optical (visual) methods are still used.

The available literature on the subject has now reached vast proportions and the selection of papers here is based on methods, application in different parts of the world, useful bibliographies, or particular relevance to museum work.

Zimmermann (74) has surveyed the various methods of dating archaeological artifacts including the tree-ring method. Stuiver (75) discusses dating by tree-rings, Carbon - 14, and varve series (layered sediments laid down in lakes) in relation to extending archaeological dating procedures beyond those at present available for tree-ring series. Hollstein (76) describes the dating of wood by the dendrochronological method and describes the series for the Rhineland which extends from the La Tène Age to the present time. Reference is made to the recovery and conservation of material. Polge and Keller (77) describe xylochronology, dating by measuring the maximum density of tree rings, using samples obtained in Switzerland. Density is said to be more strongly dependent on climatological factors and less sensitive than ring-widths to other sources of variation. In particular their use together facilitates dating and a method of plotting both measured together to obtain synchronization is explained.

Becker and Giert-Siebenlist (78) describe the dendrochronology of Silver Fir in Central Europe for over eleven hundred years. A gap in the series from 1300-1541 A.D. was bridged by material from three churches. The chronology of Silver Fir is compared with that of oak.

Bauch, Eckstein and Liese have done a great deal of work on dendrochronology in Northern Europe particularly in relation to art, architecture and archaeology. They describe the dating of oak in North Germany (79) and discuss it in relation to specimens from various sites. A standard series, such as that for South Germany cannot be constructed for North Germany and dating must be done only in relation to a narrow site. They discuss the successful dating of a monastery and an excavation site as illustrative of the possibilities of dendrochronology in North Germany. The same authors (80) discuss the development of a tree-ring series for oak in North Germany for the purpose of dating historic buildings. Bauch (81) describes the dating of the Bremen "Kogge" (a boat). This was found in the North but was made of wood from the South and was therefore dated using the South German growth-ring chronology. He also discusses the development of standard annual-ring series on a regional basis as a means of dating historic buildings and panel paintings (82).

In 1970 a meeting on dendrochronology was held in Germany. The published papers (83) cover the dendrochronological method, dating by dendrochronology and Carbon - 14, the effect on dendrochronological dating of species, wood quality and state of preservation, construction of regional standard annual ring curves for dating historic buildings and panels of paintings, (this includes a study of several Dutch paintings), judging paintings with reference to dendrochronological dating of wooden panels and other technical methods, and the application of dendrochronology to archaeology in North Germany.

Bauch and Eckstein (84) describe a modification of dendrochronological methods for the dating of panel paintings, especially those constructed of oak. A comparative study of a series of panels of Dutch paintings was undertaken. They satisfactorily proved that the date of felling of the tree could be determined in most cases and that wood had been used about five years after felling. For a study of this sort it is, of course, necessary that a tree-ring series has already been constructed for the area from which the wood is believed to have been obtained.

The sapwood is usually removed from timber before it is used owing to its lack of durability. This means that any analysis of growth rings in timber from panel paintings, furniture, etc. lacks several rings. Bauch and Eckstein (84) added 20 ± 5 sapwood growth rings to their determinations when the sapwood was entirely missing. Corona (85) studied the stems of one hundred oaks, 0-120 years old, from Central Italy and showed that the number of sapwood annual rings (y) increased with the age of the stem and that for trees within the above age limits it can be satisfactorily expressed by the formula $y = 16.4 \pm 5.4$. He discusses dendrochronological work with reference to oak timbers and furniture. Nicolaus (86) discusses dendrochronology as a method of dating works of art.

Polchin (87,88) describes the dendrochronological work done on material from Russian archaeological excavations and the creation of an absolute scale for a large area of the centre and north of Eastern Europe.

Tree ring analysis with specific reference to North West America is reported (89). This conference report covers the biology of tree-ring formation; methods of measuring tree-rings; methods of analysis and the uses of the data obtained.

Archaeological excavations in north western Arizona (90) furnished eight hundred wood specimens for examination. Experiments were designed to explain and illuminate the contributions made by dendrochronology to archaeological interpretation.

In Japan *Cryptomeria japonica* has been used for dendrochronological work. Two papers by Horibe (91,92) describe work done on trees growing at the Ise shrine and the annual-ring width analysis which was done by computer.

Corrosion of Metals

The acidity of wood (93,94,95) has generally been regarded as a good indicator of the likelihood of it causing corrosion though this may not always be so. Acetic acid, the main cause of corrosion, occurs in wood in combined form (acetyl groups), which is slowly released from wood especially under warm, damp conditions (e.g. oak, Douglas Fir, Sitka Spruce, beech and birch) (95). The conditions of initial drying may have an important influence on the acidity of any wood (95).

F.P.R.L. (U.K.) have studied the corrosion of metals by wood from 1955 onwards (96). The 1955 report describes work on the corrosion of cadmium-plated steel suspended in warm, moist conditions over various species of wood, chemicals derived from wood and from wood adhesives. Acetic acid, formic acid, oak and birch wood were found to cause corrosion. In some cases corrosion was found to be caused by salt in the wood, presumably due to the logs floating in salt water at some time. In 1956, a report was made on the production of acetic acid by eight species of wood in closed containers at 48°C and a humidity sufficient to maintain the moisture content of wood at fibre saturation point. In 1957 similar work on Douglas Fir was reported, after two years the amount of acetic acid produced was almost equal to that which could be obtained from acetyl groups originally present in the wood as determined by chemical analysis. Extended work on cadmium-plated steel included corrosion by a variety of glues. The 1958 report compares the acid production of various woods at high temperatures and moisture conditions. A further report in 1963 describes the use of propylene oxide to prevent fungal growth (which affects acid production) and discusses the corrosion of aluminium by various woods, some treated with preservatives. This work is also reported at length by Farmer and Porter (97).

H.M.S.O. have produced a paper (98) on the corrosion of metals by vapours from organic materials, including wood. Schikow (99) describes the corrosion of metals in wooden casings. Acetic acid is again the main cause of corrosion but not until air humidities have reached about 80%.

A series of four papers by Arni, Cochrane and Gray on, "The emission of corrosive vapours by wood", cover a survey of acid-release properties of certain freshly felled hardwoods and softwoods (100); analysis of the vapours emitted (101); acetyl compounds extracted from Sweet Chestnut and Wych Elm (102,103).

Ormstad (104) reports on the corrosion of metals in contact with impregnated wood.

In all the above papers and reports the temperature and humidity under experimental conditions were well above those found under normal conditions. It would appear that under normal museum conditions the likelihood of

etal corrosion caused by acids released from wood is improbable. However the conditions may possibly arise i.e. in warm, damp storage areas, in tropical countries and in extremely warm, damp summer weather.

Occasional reports of corrosion on lead and pewter museum objects remain unexplained. There is a possibility that it is due to or accelerated by acids released from wood or wood adhesives. As a precaution lead and pewter objects should not be shown or stored in cases made from wood, especially those mentioned in the above papers, unless low humidities are maintained at all times. There is no definite evidence to suggest that other metals may be corroded in museum cases by acids released from wood.

Related to the corrosion of metals by wood products is the staining of wood by iron (105). A leaflet produced by F.P.R.L. describes the cause, occurrence, prevention and removal of iron stains from wood. Vick and Taras (106) report on the staining of red oak parquet flooring bonded to on-ground concrete. This was caused by minute particles of iron reacting with wood tannins and water rising from the damp concrete.

Objectionable odours from wood were reported by Zinkel et al. (107). These were caused by several organic acids produced in two South American woods in a hot, humid atmosphere by anaerobic bacterial fermentation of carbohydrates. Similar problems occur in several species of oak and it is suggested that the shakes and honey-combing which are said to occur in this timber during seasoning may be due to bacterial action.

The evolution of formaldehyde from particleboard is reported (108,109). This is due to the urea-, phenol- or resorcinol- formaldehyde adhesives used in their production, 5 p.p.m. of the gas in the atmosphere being sufficient to cause irritation to the eyes and nose, and 1 p.p.m. being detectable. Small amounts of the gas are released from the particleboard for some time after production. As particleboards are used frequently now in interior joinery the possibility of the odour problem occurring, especially in badly ventilated and enclosed areas, should be recognized. High temperatures and humidities accelerate the release of formaldehyde. Formaldehyde is not poisonous but can cause the alarming sensation of burning eyes and nasal tissues. The gas cannot be entirely eliminated but painting or varnishing to seal the particleboard surface considerably reduces the amount of gas released and adequate ventilation should be provided.

Sorption of Sulphur Dioxide by Wood

It has long been known that sulphur dioxide as an air pollutant indoors is usually about 20% of the outdoor level, and it was assumed that the gas was absorbed and neutralized by walls, ceilings, etc. An accidental release of radioactive sulphur-35 sulphur dioxide in a laboratory provided a situation where the sorption of sulphur dioxide ($S^{35}O_2$) on to exposed surfaces could be recorded (110). The concentration of gas released was similar to those found in a polluted atmosphere. Gloss painted, clean metal, treated wood and dry emulsion painted surfaces showed no detectable sulphur. Most of the activity was found on damp ceiling areas, bare concrete surfaces and on waxed linoleum flooring. $S^{35}O_2$ was absorbed by concrete, brick tile, unpainted wood, paper, damp emulsion painted surfaces, cotton fabric and rusty and/or dirty metal surfaces. In most cases the SO_2 contamination could be removed by washing and the ease of removal suggested that it was held in fatty surface deposits.

Spedding followed up this work by studying $S^{35}O_2$ sorption on paper (111) and wood. Sorption was found to be influenced by surface finish and design pattern. Sweat deposits on the wallpaper influenced the pattern of uptake but could easily be washed off, therefore $S^{35}O_2$ is probably bound to the deposit and not to the paper.

$S^{35}O_2$ sorption by wood (112) showed different patterns for softwoods and hardwoods. The softwood sorped less $S^{35}O_2$ than the hardwood and the sites of sorption were different, in the softwood the $S^{35}O_2$ being predominately in the springwood, and in the hardwood is the summerwood. Most of the $S^{35}O_2$ was found in the outermost 0.05 mm of the wood. The possible degradation of wood surfaces by SO_2 is discussed.

Colour of Wood -- Effect of Light

The initial colour of wood depends on two things, the proportion of cellulose (white) to lignin (brown) in its cell walls and the quantity and colour of wood "extractives" present. The changes in colour of wood over a period of time are due to several interrelated causes which are not yet fully understood. Light coloured woods usually yellow or darken. Dark woods often only develop their typical colouration after felling due to oxidation of complex polyphenols, quinones etc., in the wood "extractive" content and may become darker still or bleach after long exposure to light. Highly coloured cabinet woods such as amaranth (purple), padouk (red) and tulipwood (pink and white stripes) generally lose their distinctive colour and become brown after exposure to light. Thus basically colour changes in wood are due to the yellowing of cellulose, the darkening of lignin and either darkening or bleaching of unstable coloured "extractives".

Direct sunlight should not be allowed to fall on the surface of furniture for these reasons, among others. Colour matching during restoration work often involves bleaching or staining because the new wood will not match. The changes likely to occur in the new wood should be understood or the restoration may become noticeable after quite a short time.

An ICOM publication (113) reviews the literature on the deterioration of cellulose, the effect of light, ultra-violet light, and high energy radiation.

Desai (114) reviews the literature on the photodegradation of cellulosic material and finds much of it contradictory and conflicting. The various theories explaining the mechanism of degradation of cellulose by light are discussed. Much of the work reviewed involves textiles and paper but wood is also mentioned. Kringstad (115) surveys the literature on the degradation of wood and high yield pulps by light. The article deals with the influence of light in the presence and absence of oxygen; the degree of yellowing; the formation of free radicals and the formation of various degradation products. Mechanisms of degradation are discussed. The great complexity of the underlying chemical changes and their causes is clearly explained in this paper.

A report (116) on some research on the action of light on cellulosic materials describes the loss of tensile strength and the colour changes under different conditions and discusses the ultimate effect of these processes on the surface of wood.

Kalnins (117) reviews the relevant literature on the photodegradation of wood. His research shows that volatile degradation products are formed when wood is irradiated and a quantitative determination of these products was developed into a method for studying the variables in the breakdown process. Photo-oxidation was an important part of the process; some results were obtained on the effect of wavelength of light. He shows that the quantitative measurement of degradation products provides a method for establishing degradation and may be used for a rapid evaluation of means for protecting wood from the effect of light.

The same author (118) has determined the formation of free radicals in wood exposed to light by electron spin resonance spectroscopy. Wood kept in the dark had very low radical concentrations, exposure to daylight and especially to ultraviolet light increased the radical content.

Bootle (119) finds that the colour changes in wood are mainly determined by polyphenolic compounds and quinones. He discusses the causes of colour, darkening, surface finishes, ultra violet absorbers, bleaching by the sun and weathering.

The reddening of Rhodesian Teak on exposure to light has been shown to be mainly due to a tannin (anhydropoly-leuco-fisetidin) (120).

The quantitative measurement of colour for Black Walnut Wood is described by Moslemi (121).

The graying of wood exposed to sunlight and weather and the red brown colour developed by wood exposed to light and protected from rain has been studied chemically and microscopically (122). Photolytic and photo-oxidative reactions in lignin are involved. The photolysis of lignin in ultraviolet illumination is discussed in relation to the use of ultraviolet microscopy in the determination of lignin in wood (123).

Biological Attack and Preservation of Wood

Much of the material published on the preservation of wood deals with material to be used out of doors or in building construction. This will no longer be reviewed in this series. It must be assumed that fungal attack rarely occurs in museum objects (as opposed to the building itself) and if it does it is due to an unfortunate accident or gross mismanagement. The conservation of ancient buildings is becoming increasingly common and is usually reported in architectural or archaeological journals, and specifically in "Monumentum" (124). All aspects of biological deterioration in ancient buildings are touched on by Richardson (125,126). He mentions some of the early methods of wood preservation, e.g. charring, pickling in brine, soaking in oil and pitching.

Hickin has produced a guide to the meaning of terms used in wood preservation (127). A general book on "Timber pests and diseases", has been published (128). Two papers were presented at the New York Conference (1970) on the subject of wood deterioration. Stamm (129) discussed five types of deterioration, thermal degradation; hydrolysis; light catalysed oxidation; action by organisms and physical degradation. Recommendations are made for the preservation of historic objects. Hickin (130) discusses wood destroying insects relevant to works of art. The ICOM publication "Problems of Conservation in Museums" deals with wood deterioration and treatment (113).

Insects

The F.P.R.L. (U.K.) have revised a series of leaflets on a variety of wood destroying insects: Lyctus Powder-Post beetles (131); the House Long-Horn beetle (132); the Death-Watch beetle (133), and the Common Furniture beetle (134).

Linscott (135) discusses the reasons for the increase in furniture beetle (Anobium punctatum) attack in the U.K. She believes that at least half the buildings in the U.K. have infestations of the beetle. Hickin (136) believes that attacks will increase in the United States. The beetle was initially carried to the United States, New Zealand and Australia in furniture shipments. A leaflet (137) discusses furniture beetle attack and its prevention and cure.

French (138) reports the effect of temperature and humidity on the life-cycle of the beetle.

The geographical range of the European House-Borer (House Long-Horn beetle - Hylotrupes bajalus) is now reported to be worldwide in areas where softwood timber is grown or used (139). Its incidence in Sweden is recorded (140), this apparently being linked to humidity levels. Yates (141) describes the use of radiography in studying the attack of the beetle in wood in houses. Baker (142) reports on the increase in Lyctus Powder-Post beetle attacks and the reasons for this. He also describes the attack of wood-boring weevils in buildings (143). These have long been thought to attack only damp decayed wood but they are now attacking sound wood in south-east England, accounting for one fifth of all insect attack in houses. Both grubs and adults tunnel and many never emerge resulting in damage without external evidence.

Eight wood-damaging insects which occur in Sweden are described (144). Weidner (145) reports on the introduction of several wood-destroying insects into Germany in furniture imported from India.

Two books, "Termites, a world problem" (146) and "Termites, their recognition and control", (147) have been published. Much of the material in the former of these previously appeared as a series of papers (148-157).

Control of Insects

Insecticides are included in a general book on chemicals for pest control (158). Another book (159) describes the action and metabolism of insecticides.

A paper (160) describes preventative and curative treatment for both insect and fungal attack in buildings. Another (161) describes the prevention of insect and fungal attack of wood and paper and discusses the alteration of wood by gamma-rays. The control of wood-destroying insects in buildings is described (162).

The control measures available against the common furniture beetle are reviewed (163) with specific reference to Australian conditions.

The F.P.R.L. (U.K.) revised their leaflet (164) on insecticidal smokes (γ-BHC and dieldrin) for control of wood-boring insects. Gamma-BHC is said

to be more effective than dieldrin. Harris assesses insecticidal smokes (165), the use of dichlorvos vapour (166) and dichlorvos strips (167,167a) for the control of woodworm. Stevenson (168) also assesses the use of dichlorvos in the form of slow release generators.

The changing attitudes to the use of insecticides is of considerable importance when a choice of which to use is to be made. The use of D.D.T. is now banned or discouraged in many countries. Organo-chlorine insecticides vary in toxicity, γ -B.H.C. (lindane) being of low toxicity. The older dieldrin is safe as are the natural products pyrethrin and derris. Dichlorvos (an organo-chlorine) particularly in the form of vapour strips has been recommended and considered absolutely safe. This has recently been queried (169). The strips release Dichlorvos continuously and slowly into the atmosphere giving a permanent low level of insecticidal vapour over several months. It is considered undesirable to allow any chemical to continuously pollute the atmosphere in this way although dichlorvos itself is rapidly degraded and in that sense is more desirable than highly persistent D.D.T. Dichlorvos-smokes do not have this disadvantage as they can be used at intervals and the rapid degradation of the insecticide makes it possible to fumigate a room, closing it for two or three days until the compound has disappeared.

The fumigation of movable objects in a fume-chamber is probably the safest and most desirable way of dealing with insect attacks, although no permanent resistance is conferred. If this is impossible the objects can be treated individually by painting on liquid insecticides. Attacks in the constructional members of rooms should be dealt with by fumigation with smokes such as dichlorvos at intervals when the room can be closed and sealed for at least forty-eight hours. The F.P.R.L. (U.K.) leaflet recommends that this should be continued (using γ -B.H.C. or dieldrin) at the time of emergence of wood-worm beetles (Anobium punctatum) for five to ten years or until no further beetles are seen. No insecticidal smoke can penetrate all the bore-holes so that some grubs and eggs escape the treatment and remain a source of infestation, the numbers being reduced at each treatment. In the U.K. some companies which treat insect and fungal attack guarantee the treatment for twenty years which means that persistent insecticides (and fungicides) have to be used. In buildings containing valuable and important objects the complete and guaranteed removal of all wood-damaging insects by persistent insecticides must be weighed against the possibility of a few insects remaining as a source of infection of movable objects after the use of a non-persistent insecticide.

The use of "Vapona" dichlorvos strips (and other similar products now coming onto the market) should be restricted to stores where infestation may occur but where museum staff do not regularly work. Until the situation regarding this insecticide is clarified its use in strip form cannot be recommended.

Fungal Attack & Control

Fungal attack should not occur in museums, but the need for a method of evaluating wood preservative treatment has long been felt. Many museums now show movable wooden objects in the open air or in only semi-protected conditions, so several papers dealing with preservative evaluation will be mentioned here.

Cockroft (170) deals generally with timber preservatives (fungicides) and the methods of treatment available. Heertjes and de Jong (171) discuss reactive fungicides and how they may be bound to wood to increase their efficiency. Da Costa et al. report on the laboratory evaluation of wood preservatives (172,173,174,175,176) and on the evaluation of fungicidal preservatives for superficial treatment (177). Gibson (178) reports on an evaluation scheme for fungicidal and insecticidal preservatives. Levi (179) and Smith (180) describe rapid tests for evaluating the fungicidal activities of wood preservatives.

Bacterial decay in wood, the importance of which has only been recognized in recent years, is reported in three papers by Greaves et al. (181,182,183).

The use of ethylene oxide as a disinfectant for ancient wood has been studied (184).

The toxic hazards from wood preservatives are discussed by Barnes (185,186). In the U.K. the safety record has been extremely high and a survey of workers in the wood preserving industry has indicated that no injury or illness due to their work has occurred. Nasal cancer has been reported in furniture makers and wood machinists; the carcinogen is believed to be a natural compound of wood. Wood dust has not previously been recognized as a hazard as it is held in the nose and wood preservatives and other compounds do not reach the lungs.

In other countries several deaths have occurred among unprotected workers using pentachlorophenol (PCP) which is able to penetrate the skin. Small children are particularly sensitive to PCP, fifteen were ill and two died after their clothes were washed in PCP contaminated water. Borates are toxic but can only penetrate through damaged skin. Alkyl tin salts are also toxic. The metabolic action of these wood preservatives is described. The safety precautions laid down should always be followed when using wood preservatives. The toxicity of several insecticides is also discussed.

Jedrzejewska (187) reports on the influence of wood protecting agents on the destructive process in antiquities. She found acidic vapours given off by many organic derivatives used in wood preservation and reports that the process was accelerated by high humidity, ultraviolet light and heat. She warns that the small and slow effects of these vapours on the deterioration of antiquities must be watched as in time they may cause serious and irreversible damage.

Furniture

History, Construction, Restoration

Two books have recently been published which deal with the recognition of repairs, restorations, conversions and reproductions of antique furniture. The authors are both cabinet-makers with personal knowledge of the "tricks of the trade". Hayward (188) covers English furniture of all periods. He discusses what to look for: the wood, the constructional techniques of the periods, period styles and marriages. He deals in some detail with the construction of chests, case furniture, tables and chairs and of drawers, doors, legs and mouldings, veneers, inlay, marquetry and finishes. The book is well illustrated with line drawings and photographs of types and constructions.

Crawley (189) deals specifically with eighteenth century English furniture and suggests that a large amount of so-called eighteenth century furniture must in fact be reproduction or fake. He describes his own experience of restoring, cutting down and 'faking' and explains what can be done. He tells where to look and what to look for when examining furniture. He describes how a Victorian chest-of-drawers was converted into a "Sheraton" chest-of-drawers. The book contains a glossary of furniture types of the period and is illustrated with photographs.

Collier and Dixon, having been trained as craftsmen, are both now college lecturers on different aspects of furniture. Their book (190) on mending and restoring furniture discusses what should or should not be done, tools, repairs to cabinets, tables, chairs and surface finishes. A section is devoted to repolishing and working with modern materials.

Grotz (191) describes the restoration of furniture. The book is full of practical advice and hints on how to do it (perhaps more for the amateur than the professional), and dispels many myths. This is an informative book if the reader can bear with the jokey humour long enough to read it.

Bateman (192) discusses the transformation and improvement of Victorian furniture. The book has a general review of Victorian furniture, what conversions are possible and descriptions of some conversions. It deals with what to do but not how to do it.

Joyce (193) has written a book which covers every aspect of furniture making for the craftsman. It is an encyclopaedic text-book of furniture making today, covering tools and workshop equipment, materials of all types, technical information concerning wood, basic techniques and constructions, examples of furniture and how to make working drawings. Everything is illustrated with line drawings and photographs. This is an excellent reference book.

A book by Gottschall (194) on the reproduction of antique furniture deals exclusively with American furniture and the American versions of Queen Anne, Chippendale, Hepplewhite and Sheraton styles. There are chapters on fundamental cabinet-making, furniture finishes and hardware. The remainder of the book contains working drawings, photographs, materials required and details of how to make thirty-seven pieces of furniture.

Several small books on different aspects of wood-working for the amateur by Hayward (195, 196, 197, see also 188) cover making furniture, hammer and nails carpentry and polishing and staining. Collischon (198) describes simple methods of furniture construction and veneering.

The renewal of interest in veneering and marquetry has produced several books. Villiard (199) has written a detailed practical manual of veneering for the craftsman. Lincoln covers marquetry in detail including including a section on the reproduction and restoration of veneered furniture. The book describes and illustrates the different methods in use in different countries in the past and today (200).

Campkin's book (201) on marquetry describes how to do it for the amateur rather than the craftsman.

De Plas (202) discusses marquetry in eighteenth century French cabinet-work and describes how it was done and the woods used.

A practical book of turnery (203) contains chapters on the history of turnery and tools, modern tools, lathes and methods and working drawing and designs for modern tree and small furniture. F.P.R.L.(U.K.) have produced a book on joinery (204).

Kilby, a cooper, has written a book (205) about his craft including sections on training, the different branches of coopering, machine coopering, tools and timbers and the history of coopering from its beginnings to the present day when it is a dying craft. He describes all the articles which were and are made by coopers: barrels, household and agricultural vessels and furniture.

A book on woodcarving for beginners (206) contains chapters on wood, tools, sharpening tools, relief carving, chip and surface carving, plates, dishes and bowls, carving in the ground, texture and finish and lettering.

The Centre Technique du Bois has published three papers (207,208,209) on stains and colouring agents used on furniture, staining and bleaching in relation to the application of polyester finishes and staining, bleaching and the application of all types of finishes.

A paper (210) deals with furniture surfaces and finishes of all types including veneers and printed veneer finishes.

Oliver (211) discusses the development and structure of the furniture industry from its beginnings to the present day. The book covers industrial theory in relation to the furniture industry and the structure and organization of the industry today.

A paper (212) reviews research of interest to the furniture industry.

The making of reproduction antique furniture by six Belgian factories today is described (213). In all cases the furniture is traditionally handmade but modern production methods and accessories are used.

Conservation of Wooden Objects other than furniture

Conservation techniques used on polychrome sculpture may sometimes be applicable to furniture conservation and several papers are therefore being included in this review. Many of these papers were published in the proceedings of the New York "Conference on the Conservation of stone and wooden objects" (214) and in an issue of "Studies in Conservation" (215) devoted to polychrome sculpture.

Ballestrom (216) prepared a bibliography on polychrome sculpture of all types (not only wood) and aspects of the subject (283 titles).

Aberle and Koller (217) discuss the problems and prerequisites of conservation treatment and include a historical review of materials and techniques and a critical review of preservatives and consolidants. Packard (218) specifically describes the consolidation of wood sculpture. Agrawal (219) describes the technique of construction and carving of Indian polychrome sculpture and identifies the species of wood used.

Papers describe all types of polychrome sculpture in Japan (220), the restoration of Buddhist statues (221), a traditional method of repairing Buddhist statues (222) and the construction of one (223).

Other papers describe the conservation of individual sculptures from India (224), Sweden (225), Norway (226), Czechoslovakia (227,228), Poland (229), Belgium (230,231,232), Germany (234) and Egypt (235,236).

Taubert (237) discusses the aims and techniques of wood conservation in general and stresses the importance of a real understanding of the objects and the need for sensible climatic regulation for exhibitions.

A handbook on the preservation and restoration of musical instruments (238) and three papers on restoration and care of historic wooden wind instruments (239,240,241) have been published.

Several papers describe the technical examination, reinforcement and conservation of wooden panel paintings (242,243,244) Seymour (245) discusses the desirability and methods of retaining the original panel construction and supports of early Italian paintings so that historical evidence may be available.

The special problems involved in the conservation of ethnographical wood is described by Gowers (246); the consolidation of soft wood artifacts by Schaffer (247) and the conservation of wooden objects from the Heijo Palace (mainly writing tablets) by Iwasaki and Higuchi (248).

The damage caused by the flood in Florence to wooden works of art is described (249) and also the conservation of similar objects after the Venice flood (250).

Three Polish papers discuss wood as a material in ancient objects (251) the structure of wood excavated at Szczecin (medieval) (252) and the species used in the manufacture of objects of everyday use found during the same excavation (253). The species used to construct panels and sculpture (13th-16th centuries) in Poland and their frequency of occurrence is reported (254). The species used for sculpture in South Poland (12th-15th centuries) with information on evidence of workmanship, historic background and the qualities of the object are discussed (255).

Adhesives for Wood

The number and variety of wood adhesives on the market today make the problem of deciding which glue to use for a specific purpose increasingly difficult. F.P.R.L.(U.K.) have produced three leaflets on aspects of gluing wood. "Glues for Wood", (256) lists the glues available, their durability and uses. "The Efficiency of Adhesives for Wood", (257) discusses the research carried out over a period of up to twenty years and briefly records the results. A fifth edition has been published of "Requirements and Properties of Adhesives for Wood" (258). This bulletin contains durability testing techniques; the processes by which glues set and a description of glues used in the U.K.

Much research on wood adhesives today is directed towards the gluing of plywood or particleboard, sometimes using a specific glue or a specific timber. This work has little relevance here. However some of the articles

contain good reviews of the literature on gluing and information on new glues. Several of these papers are included here.

Halligan's "Revue of recent glues and gluing research applied to particle board" (259) contains a brief discussion of adhesion in general and sections dealing with specific aspects of recent research. Wood factors relevant to adhesion are covered [99 titles]. Blomquist (260) discusses more specifically the gluing of Southern Pine [53 titles]. Pecina (261,262) covers the more technical aspects of wood moisture and its inter-relation with other factors in wood adhesion [63 titles + 7 titles].

Hse (263) discusses the properties of phenolic adhesives as related to bond quality in Southern Pine plywood. Thirty six resins were tested and the results of these tests are given. Another paper on phenolic adhesives (264) discusses how they may be tailored to fit specific requirements.

Shelton (265) reports on the adhesives used in plywood manufacture (most commonly used glues) and discusses their advantages and disadvantages.

Vick (266) evaluates elastomeric adhesives (neoprene; styrene-butadiene; rubber: synthetic, reclaimed and natural; polyurethane, etc.) used in construction work.

P.V.A. adhesives suffer from being non-durable under damp conditions, Vojtovic (267) describes how water resistance of P.V.A.-water emulsion adhesives may be increased.

Moisture Measurement

There are three commonly used techniques for measuring the moisture content (M.C.) of wood. The oven-drying method (268) involves the removal of a small sample of wood which is weighed and placed in an oven at 101-105°C until a constant weight is obtained; the moisture content is then:

$$\frac{\text{Initial weight} - \text{dryweight}}{\text{dryweight}} \times 100\%$$

The chosen temperature is just above the boiling point of water but not high enough to cause charring (chemical breakdown) of the wood. It is not always possible to remove wood samples, or convenient to wait several hours for the results, and electrical moisture meters are used then. There are two main types; the electrical resistance moisture meter depends on the principle that the electrical resistance of wood is linearly proportional to the M.C. of the wood. This is only true up to the fibre saturation point (ca 25-30% M.C.) (269) above which an increase in M.C. has no effect on the electrical resistance. Below 7% M.C. the resistance falls off too quickly to calibrate the meter accurately. Therefore this meter may only be used to record the M.C. of wood over the range 7%-25% M.C. This covers the normal range of wood in use. A true reading of M.C. is only obtained under equilibrium conditions; the highest M.C. will be recorded and pockets of high M.C. or moisture gradients will therefore give a M.C. reading higher than the true average M.C. The meter is temperature sensitive and corrections must be made for this. Two blade or needle electrodes are implanted in the material to a depth of 6mm; little damage to the wood results from this.

The second type of meter depends on the variation of the dielectric constant of wood with M.C., using radio-frequencies with two flat electrode plates attached to either side of the wood to be measured (269). The dielectric constant increases in a non-linear manner with an increase in M.C., becoming almost linear at the fibre saturation point. The dielectric constant of water is the limiting factor. It is sensitive to temperature, specific gravity (which varies with species) and to chemical impregnants; the correction factors for timber species are usually supplied in the makers manual. The apparatus requires frequent calibrations. This meter in no way damages or marks the wood.

Three recent publications discuss these methods of measuring M.C. of wood. A French paper (270) describes the oven-drying and electrical resistance methods, stressing the advantages of the latter. This paper contains twelve maps of France indicating the M.C. of wood, air humidity and average temperature of different areas for each month of the year.

Harrison (271) describes all three methods and discusses the temperature coefficient and also the effect of glues and preservatives in the wood. He includes two tables: 1. Meter readings corrected for temperature and 2. corrections for 188 species for a meter (electrical resistance type) calibrated for Douglas Fir.

Saunders (269) discusses the types of meters and techniques and precautions for use. Results are usually indicative rather than exact, and if accurate measurements are required the over-dry method should be used. He gives a

list of manufacturers (worldwide) producing a total of 51 meters, with prices ranging from £12.50 to £270.50. The author discusses in detail the precautions to be taken when using moisture meters, their advantages and disadvantages, range of M.C. over which they can be used, etc.

Dean and Bridle (272) give an account of trials with a new type of moisture meter (1969) which passes a beam of microwave energy through the wood under test and measuring the wavelength losses (attributed mainly to the presence of water-molecules). The most important advantage of the meter is its ability to record average M.C. despite the presence of pockets of high or low M.C. The equipment is large, heavy and expensive (ca £500).

Hill and Munkittrick (273) report on the development of a remote moisture sensing device, for use in kilns during drying. The apparatus is a development of the electrical resistance meter.

A series of probes are placed at various points in a sample board or boards in the kiln. The measurements can be continuously read over prolonged drying periods on meters outside the kiln, the several probes indicating the moisture gradients present in the boards.

Each probe consists of a hard maple element (Acer saccharum) 0.07 in.sq. by 0.75 in. long with copper constantan thermocouple leads bonded with conductive epoxy resin to one surface and a single copper lead to the opposing surface. The leads are covered with a shrinkable polyolefin tube and the whole probe sealed into a small hole drilled in the experimental board. The uncovered maple tip of the probe is sufficiently responsive to changes of M.C. in the board for the reading made upon it to reflect accurately the M.C. of the adjacent board. The temperature is also recorded.

Koslik (274) has used the electrical resistance meter and the radio-frequency power - loss meter to record the moisture content of fifty samples of wood which were then oven-dried to obtain an accurate measurement. The moisture content determined by over-drying was lower than that obtained by the power-loss meter and higher than the resistance meter readings. The density of the wood affected the power-loss meter readings.

Moisture content of wood in use

Literature on the seasoning of wood is not relevant to this review; much of the material is contained in review articles such as Loos' "Wood drying review" (275).

Today most wood is seasoned to suit its final environment, eg. for a well-heated living room wood is seasoned to 12% M.C. allowing for a 10% M.C. at the end of winter, and a 14% M.C. in autumn. The F.P.R.L. (U.K.) have revised a paper (276) on the moisture content of timber in use which contains a chart indicating the average M.C. in a number of environments. The variations in M.C. due to species and to previous treatment of the wood are small and can be ignored except for very exact work. The necessity of seasoning, the possibility of wood constructions swelling in new, damp buildings (where the M.C. may rise to 18%), the occurrence of fungi when M.C. exceeds 20% and other aspects of wood moisture content are mentioned.

Crow (277) discusses the changes brought about by large-scale kiln drying in recent years and suggests that imported wood should be seasoned for use rather than for shipment in its country of origin. He believes that a 16+3% M.C. would be most appropriate.

Tsoumis (278) has computed equilibrium moisture contents for wood from weather data. The difference between these values and actual values of wood specimens from nearby sites (exposed to the atmosphere but under shelter) varied from 0-2.8%. The computed value may thus serve as an estimate of expected moisture content. Applying this method Tsoumis has plotted isohygric lines on two maps of Europe (for July and January) from M.C. computed from weather data of average monthly temperature and relative humidity.

Simpson (279) has produced a formula which can be used to predict the equilibrium M.C. of wood. It is based on sorption theory and data and gives equilibrium M.C. values from temperature and relative humidity data which agree well with tabulated values. The use of this formula reduces the need for tabular data or computer storage of large quantities of data.

Borovikov (280) has presented a nomogram for calculating the density, maximum moisture content and coefficient of volumetric shrinkage of wood. He gives examples of its use.

Keylworth (281) presents the results of equilibrium M.C. determinations on 124 wood species at 20°C and 37% or 83% relative humidity. Using an approximated equation intermediate values may be interpolated and practical data for the hygroscopic properties of wood species can be defined. The equilibrium is not the same for all woods and these differences may be significant for the extent of swelling over a defined climatic change. The exceptionally low swelling shown by some wood species is due to their very low hygroscopicity and is much less than would be expected from the wood density.

The E.M.C. of thirteen Indian Species of wood at 95° and varying relative humidities have been determined (282). The average M.C. values during absorption and desorption were calculated and curves drawn.

In Japan (283) the E.M.C. of air and kiln dried Fagus crenata and air dried Cryptomeria japonica in a shelter, in offices or in houses has been correlated with temperature and relative humidity over a period of two years in fifteen areas.

A detailed study of the wood-water relationships of Pterocarpus dalbergioides (Padouk) has been made (284). This wood has a low E.M.C. (14% at 96% RH, 4% at 30% RH at 35°C). It has traditionally been divided into three colour groups which also have distinct specific gravities and are here shown to have quite different E.M.Cs., the densest wood absorbing least water. Five tables are given relating, variously, E.M.C., density/water absorption, density/shrinkage/M.C., density/swelling/M.C., density/swelling/shrinkage in tangential and radial sections.

It has been suggested that the hygroscopicity of woods of low specific gravity could be utilized to make humidity buffers in enclosed areas such as packages where sudden temperature changes occur (285). The authors have shown that some lighter woods not only have a greater capacity to absorb or give up water but do so much more rapidly than do dense woods (see also 281 and 284). Denser woods show a considerable difference in their rates of absorption and discharge, the former being very low. The woods suggested are Japanese, (Paulownia, Cryptomeria, Japanese cypress) but the reviewer suggests the possibility that woods of similar character could be found in Europe, America etc.

Kelly and Hart (286) studied the absorption and desorption rates of Liriodendron tulipifera and Quercus alba at 40°C in the absence of air. The rates of both were much slower than expected from Fick's diffusion laws. Heat transfer to the specimen was important in limiting the rate of moisture change, especially in desorption. An empirical equation is developed.

The previous history of sections of Araucaria hunsteinii proved to have an effect upon the sorption of water by the wood cell walls (287). The longer the period during which the sample had been exposed to a vapour pressure producing a M.C. of ca 10% (1-120 hour) the slower was the uptake of water when the sample was placed in a higher humidity, particularly when the second humidity was only a little higher than the first (e.g. from 10% - 13%). The authors suggest that some energy from water uptake is temporarily stored and only slowly released by the complex molecular rearrangement that ultimately leads to the most stable state. Residual energy from the first step may therefore become available to augment the energy from the second. The speed of sorption process is usually related to swelling stresses in the cell wall. This latest theory likens the phenomenon to stress relaxation in the rheological sense. The importance of the sorption and stress histories of experimental samples is emphasized.

Shrinkage of wood

Khanmamedov (288) reports that the end of swelling or start of shrinkage does not coincide with the fibre saturation point but tends towards the side of higher M.C. He divides the total M.C. range over which dimensional changes of wood occur into three sections:

1. Linear relationship from 0 - 16% M.C.
2. Section of convex curve from 12 - 32% M.C.
3. Section of 2nd convex curve from 24 - 55% M.C.

He explains the process mathematically.

Siteva (289) describes the effect of temperature on the shrinkage of wood. Three species of wood at 70% M.C. were dried to 7-8% M.C. at 60, 70, 80, 90, 100 and 110°C and their volumetric shrinkage determined. The shrinkage of the 2 softwoods increased as the temperature increased from 60-80°, showed no change from 80-90 and decreased at the higher temperatures. The shrinkage of beech decreased as the temperature increased.

Movement and warping of panels

The F.P.R.L. note (290) on the movement (shrinkage) of timber has been revised and a standardized method for measuring this in the radial and tangential directions is described. A table listing nearly two hundred species gives the E.M.C. at R.H. 90% and 60% and the corresponding tangential and radial movement. The timbers are then classified into three groups of small, medium and large movement values.

Hartwig (291) discusses the possible causes and prevention of warping in coniferous wood. Trunks of Pinus radiata have a higher M.C. near the bark

and at the top than near the pith and at stump level and these variations are partly responsible for warping during seasoning. Methods used in seasoning are discussed which would help to prevent warping.

Lutz (292) discusses the causes and prevention of buckle in veneers. He considers the primary causes to be the direction of slicing (growth stresses in the wood), differential drying, the presence of tension and compression in wood and of irregular grain. He suggests that it can be controlled by careful selection of timber, heating to release stress, choice of cutting direction, dimensional stabilisation and control of drying. He also mentions treatment after drying and buckling.

Tamburini (293) describes the alterations in panel paintings caused by variations in the M.C. of the wood. Kubler (294) discusses the bowing of panels in a one-sided atmosphere (mainly entrance doors to buildings). The arguments can be equally well applied in the less extreme conditions obtaining in furniture panels and doors. Several methods for minimizing or avoiding bowing such as the use of thin metal foil are analysed and compared technically and economically.

Longitudinal shrinkage

The longitudinal shrinkage (L.S.) of wood is so small that it is frequently ignored. Sadoh and Christensen (295) have studied L.S. and showed that it is negligible or negative from green to 12% or even 8% M.C. and then increases with further drying. Comparative figures show that tangential shrinkage varies from 6-12% of green dimensions whereas longitudinal shrinkage is only 0.4% of green dimensions.

Hann (296) reviews past work on L.S. and discusses various theories which try to explain negligible, negative and positive L.S. at different M.C. He gives the experimental results of measurements of L.S. on seven American species. The two outstanding characteristics are the extreme variability shown and the negative L.S. which in some cases extends to very low relative humidities. Neither the distance from the pith nor the density of the wood could be correlated with the L.S. and the author agrees with an earlier suggestion that the variation in microfibril angle in the cell walls is the main cause of variation in L.S.

A Dutch report (297) gives data for the L.S. of seven timber species.

Moisture Sorption of excavated wood

Dzbeński (298) has compared the swelling anisotropy (ratio of tangential and radial swelling) of excavated oak (10-11th centuries) with normal oak and bog oak. It was less in excavated oak than for normal oak, but its moisture relationships curve was the same. It is suggested that such material could be preserved for museums merely by careful drying and dry storage. He has also (299) compared normal oak wood with oak wood from excavations (400-2500 years old) in relation to its conservation. By measuring the volumetric swelling he has found it possible to give directions for preservative measures. The chemistry, density and bending and compression strength of excavated wood of several species has also been studied (300).

Optical techniques for the measurement of strain and movement

McKenzie (301) describes the use of grid patterns applied to wood to investigate the strains associated with the penetration of a cutting edge. The grid was applied photographically to a white epoxy-paint over an area $\frac{1}{4}$ inch square using a mesh of 0.01 inch. Other methods of application were investigated.

In Japan photoelastic coatings have been used to measure strain (302) in plywood and solid beams. The strain patterns obtained are illustrated.

Hoadley (303) has used a moire transfer grid technique to study compression set in restrained wood discs.

Suchsland (304) used an optical comparator to determine linear expansion and contraction of wood products. The instrument reduces the need for calibration and eliminates the difficulties associated with measurements requiring physical contact between the specimen and a gauge. Expansion and contraction can be measured to $10\mu\text{in/in} \pm 20\mu\text{in/in}$. The theory and calculations are included.

Wood rheology

Schniewind (305) reviewed progress in the study of wood rheology in 1968.

In 1969 research in wood rheology was assessed (306). The authors discuss the favoured lines of research and suggest that future research should be concentrated on filling in the existing gaps. They criticize creep experiments where far-reaching conclusions have been based on studies lasting only hours or minutes. They suggest that the study of deflections of loaded wood during changing M.C. and repeated cycles should take high priority. They also criticize the use of specimens free from defects in all experiments where their presence would be useful and informative.

Buck (309) has applied rheology to the treatment of panel paintings. He discusses types of warping, bending, elasticity and plasticity, the rheological behaviour of wood, and describes experiments on the rheological behaviour of wood blocks at a M.C. of 15-20%. He describes in detail the successful treatment of a panel painting attributed to Rubens to remove a concave warp.

Many of the large number of papers published on studies of creep and wood rheology are not relevant (e.g. experiments conducted under constant climatic conditions, during drying from the green state, during drying after boiling in water, after oven-drying, etc.).

Fujita (308) has revised the recent literature on the effect of applying tensile stress to wood on its behaviour (including deformation and checking) during drying in relation to wood rheology.

Borovikov (309) reports the results of experiments on the effect of M.C. and temperature of wood on its elasticity, plasticity and viscosity. The results are presented in tables, graphs and nomograms.

Chow (310) has studied the deflection of composite furniture panels (particle board and walnut veneer) under constant bending stress and various M.C. He

and that a reliable long term creep prediction could be made from creep tests lasting 10-100 minutes. The panels had only about one quarter of the creep resistance of solid walnut panels of the same thickness. Veneer on the sides of the panels increased their resistance to one half or three-quarters of that of the solid panels.

Stak (311) describes the effect of M.C. changes on the rheological properties of Scots Pine wood compressed across the fibre. The fibres were compressed tangentially or radially at four different levels of compression for twelve hours and the M.C. was increased at intervals relative to the initial M.C. at which it has been conditioned. He lists the conditions under which deformation occurred. The changes in M.C. may intensify the creep or sometimes partially arrest it. Deformation generally increased with increases in M.C. and load. Wood compressed in the radial direction shows a tendency to creep more than tangentially compressed wood under the same conditions.

Przykowski (312) studied the effect of relatively rapid changes of M.C. on creep and found increases in the creep process caused by a combined effect of external forces and moisture stresses. Depending on the conditions during the process (load, increase or decrease of M.C.) a total failure or the stabilization of the creep can occur at a level which approximately corresponds to that before changing the M.C. of the wood. An attempt is made on a hypothetical basis to explain the observed phenomena which leads to the suggestion that the creep process is invariably accompanied by failure.

Reiter and Reiter (313) studied the relaxation of bending stress in a beech-wood beam loaded at one end in a climatic chamber under controlled conditions of humidity and temperature. M.C. varied from 7-20% and temperature from 0-90°C for periods of 50 hours. Relaxation processes show a marked increase with increase in M.C. and temperature and are shown graphically in relation to time.

Creep relaxation has also been studied during the absorption of water in wood (314). The relaxation was less during constant M.C. (range of 1%-24% tested) than during absorption when the relaxation modulus decreased rapidly and then increased slightly. It is concluded that the relaxation depends on the diffusion of water vapour and is affected by internal stresses set up by moisture gradients.

Reiter (315) has investigated the influence of load under cycling climates on the deformation of wood (constant temperature, relative humidity 30%-90%). He observed an increase in deflection during the drying periods and a decrease during moistening. The assumption was made that by means of water transport during drying some cellulose-water-cellulose bonds are opened and when reformed at other sites under the influence of the external load. At high loads the coherence of the wood tissue can be weakened so much by the opening of bonds that defects in the fine structure can be observed with light microscope.

Wasserman (316) describes two methods by which wood samples can be weighed during rheological tests to determine changes in M.C.

Moisture Barriers

A review of wood/coating interactions briefly describes wood structure and chemistry and discusses the work already done and the importance of the study of wood-polymer interactions (337). The porosity of the cell walls in dry wood is 2-4% as compared with 25% for water swollen wood, swollen wood allows the penetration of various polymeric materials. The force of adhesion between the wood and its coating is usually explained in terms of intimate contact between the polymer and the wood but if outer surfaces only are considered this does not account for the total force of adhesion. It is suggested that diffusion of polymer into the cell wall takes place the resulting entanglement increasing the force of the adhesion. In this case the factors affecting the adhesion would be the depth of penetration into the wood substance, the strength of the covalent bond in the polymer chain and the strength of the wood substance just below the penetrated area. Further penetration into the inner volume of the cell wall could act as a dimensional stabilizer, this is important because differential movement between the wood and its coating is a prime factor in the breakdown of adhesion during weathering. The author suggests that more knowledge of the penetration obtained and the interactions occurring could lead to controlled penetration by a selected coating which would give increased stability and durability. The relationship between surfaces and coatings on paper and wood was the subject of a Symposium held in 1967 (338). The flow properties of latex, concentrated solutions and polymers and fibrous suspensions were the subject of one section, another being molecular forces at interfaces, absorption from solution and wetting of solids by liquids and the significance of hydrogen bonding at the surface of a cellulose network structure, and the third mechanisms of the wet strength development of paper. The surface characteristics of wood and cellulose, methods of wood finishing, pigmented coatings and polymer films as coatings were also discussed (see 339). A method of studying the various types of interface between wood and adhesive and lacquers using scanning and transmission electron microscopes has been described and illustrated with photomicrographs, a polyester **lacquer** was used in the study (340). Criteria for judging the quality of a surface to be coated are discussed and the factors that lead to poor performances identified (341). It is possible that the stiffness, thickness and elastic modulus of the coating can be adjusted to suit the nature of the base material and the choice of a suitable material is illustrated by examples. This work was mainly carried out on particle boards and is of more importance in commercial practice than conservation work.

The effect of wood structure on the durability (in the sense of having good adhesion, that is lack of tendency to flake) of paints applied to it has also been considered (342) and it was found that surface texture of the timber as well as its stability was important. The durability of clear coatings on wood species which have a fine surface texture was better than on those with a coarse texture and greater dimensional stability. The best performance being on timbers with a fine surface texture and good dimensional stability. The blistering of paint on pine wood was also found to be influenced by the wood structure (343). Heartwood gave more blistering than sapwood, radially sawn more than tangential, the density of the annual rings had no effect in heartwood but in sapwood with dense annual rings radially sawn planks gave more blistering than other combinations although in general the higher the density of the timber the lower was the blistering. Pretreatment of the wood by soaking in water at different pH's and temperatures, treating with steam, heating and soaking in ethanol solutions led to the conclusion that extractable constituents of the wood which diffuse to the wood-paint interface under the influence of heat or moisture or both in combination are responsible for the blistering of the paint rather than heat or moisture alone.

a study of the causes of adhesion failure of epoxy resin coatings on wood, stresses developing during curing at room temperature were detected by polarized light. The effect of film thickness, specimen thickness, degree of dilution with solvent and growth ring structure are described and illustrated (344).

Another surface factor affecting the durability of paints on timber which has been studied is the temperature reached by the wood just below the surface of the coating. The effect of colours, matt or glossy surfaces were measured at temperatures ranging from 40 to 80°C detected in summer sunshine. Measurements were made at different depths in the wood. The effect on the durability of the coatings was discussed. (345) (346).

A review of the requirements for various types of polymer films for use as coatings (339) gives permeability figures for permeability to water and oxygen of different polymer films. Polymer films applied from a melt may have different properties from the same polymer when cast from a solution by evaporation of a volatile solvent. The time to establish equilibrium is important in measuring permeability, for example, thin films of nylon take only 15 days to reach equilibrium, thick ones may take over 100 days. (Even 100 days is a long time when considering the effect of the rapid fluctuations in humidity which take place in a museum gallery - reviewer's note). Relatively small changes in the chemical nature of a polymer affecting the degree of polarity change the permeability of the material, for example, changing the acetyl content of cellulose acetate from 34-43% changes the permeability by a factor of ten, oxidation of polythene (only 0.6% by weight) changes the permeability by a factor of five. The hydrophilic or hydrophobic nature of the film affects the permeability, for example, hydrophilic polyvinyl alcohol is 4000 times more permeable than hydrophobic polythene. But the permeability is a combination of two factors, the solubility of the permeant (substance passing through the film, usually water vapour in museum context) material in the polymer and the mobility of the permeant molecule in the polymer film. The mobility of the water molecule in a polyvinyl acetate film is eighteen times smaller than in polythene but the number of molecules sorbing and diffusing in the polymer is eight thousand times greater in a polyvinyl alcohol film than in a polythene film (339).

The influence of the solvent on the permeability of films which are applied from solution, such as paints and lacquers, has been studied. It was found that the polarity of the solvent has a definite influence on the permeability of the film (when the solvent has completed evaporated). The closer the structural similarity between the resin and the solvent the lower the water vapour permeability, differences of 20-50% were found. This difference is considered to be due to the fact that the orientation of the molecules in the film could be influenced by the nature of the solvent, favourable molecular alignment (for low water vapour transmission) being obtained when the resin and the solvent are structurally similar (347).

Theoretical studies of the permeability of paint films to water and water vapour (348) have shown the permeability to be determined by two processes (see also (339) 1). Diffusion characterised by the diffusion coefficient, the mobility of the permeant molecule in the film 2) absorption characterised by the solubility coefficient, the solubility of the permeant molecule in the film. The permeability coefficient is a product of the diffusion and solubility coefficients, the diffusion coefficient is difficult to measure, the other two can be measured by standard methods. The theory of permeability

involving this three stage process, sorption of the permeant molecule (water vapour or gases) into the surface of the polymer film, then diffusion to the other surface and desorption from the film has been described in many reviews of the permeability of polymer films. (349,350,351,357,368).

Perera (349) found the permeability coefficient not to be constant but to be dependent on the water concentrations inside the film. His experiments were with non-pigmented films of hydrophobic and hydrophilic materials. Permeation measurements give the permeability coefficient which includes both diffusion and sorption coefficients which may act in the same but also in opposite directions. In the case of hydrophilic films where swelling is caused by sorption of the water vapour the rate of diffusion of water vapour may be increased or decreased depending on the structure of the polymer. Lebovite (351) describes the permeation process as transport due to permeant dissolving in the permeable membrane on the high concentration side then diffusing towards the low concentration side; a process which depends on the formation of holes in the plastic network due to thermal agitation of the chain segments; and finally being desorbed on the side of lowest concentration. In this process the chemical composition of the membrane and permeant is important penetrants chemically similar to a film permeating faster through it than those which are dissimilar. The nature of the permeating material can make a difference to the rate of permeation. In addition to the chemical composition the size of the penetrant molecule and its ease of condensation (in the case of gases) affect permeability of a given film. Film properties which affect its permeability to a particular vapour are its chemical cross-linking and crystallinity and plasticisation and its degree of swelling by the penetrant molecule or other substance which may be present and sometimes the previous history of the material. If the network of the polymer is "tight" due to crosslinking or crystallinity or strong cohesive forces brought about by chemical similarity it will resist the formation of holes for diffusion. If the network is loose due to plasticiser, swollen by some solvent or the chemical structure contains double bonds diffusion will be easier. Temperature increases permeability exponentially if the permeant does not swell the membrane but is more complex when swelling occurs due to increasing condensation and solubility, the plasticizing effect then increasing permeation (351,358). Lebovite (351) says that the permeability of a given polymer film can be calculated in simple cases and this possibility is mentioned in other papers. Hennessy et. al. (352), quotes the example of a vinyl chloride/vinylidene chloride copolymer where the permeability can be correlated with the chemical composition (353,354,355,356). They also found permeability to increase with temperature except in the case of hydrophilic films such as nylon and polyvinyl alcohol where the effect is reversed for water vapour. Also of interest is the finding that the same type of polymer from different manufacturers may have different permeability probably to differences in crystallinity, plasticiser content and chain length. A correlating parameter called "permachor" has been derived from the measurement of oxygen permeability and knowledge of the structure of polymers. Using the "permachor" the oxygen permeability can be predicted to within 10% of the observed value. Properties of the polymer such as chemical nature, backbone structure, side chains etc. and morphological considerations such as crystallinity are incorporated to give a numerical value which when inserted in the derived equation gives the oxygen permeability at 25°C. Less precise relationships were derived to estimate CO₂ and N₂ permeabilities but water vapour was not included in this work (probably the permeability to water vapour would be more complex due to its ability to swell many polymer films - reviewer's note) (355).

effect on permeability to water vapour of stretching a polyurethane resin film has been measured to simulate stressing in service as a wood coating (359). It was found that the permeability to water vapour was changed at 0.2% elongation but at elongations above this increased sharply returning to the original value when the stress was released even after 10 years in the stretched position. With ethanol vapour the permeability was independent of elongation. To explain this finding it is postulated that reversible expansion of the polymer network takes place under stress.

McBane (360) has found that the permeability of moisture through a paint film on a wood surface is different from that of the free film and suggests that the swelling of the wood base caused by adsorption of moisture expands the paint film and that subsequently this expansion gives rise to high permeability through the paint film on the surface. This result agrees with the work in reference (359) and shows that permeability measurements normally carried out on detached films may not give the same results as those obtained in practice on substrates.

The permeability of multicoat films has been shown by several authors to be related to the passage of water through the least permeable film (361). Paint systems having a primer able to sorb more moisture than the topcoat retain more moisture for longer periods of time than when the topcoat has sorption equal to or greater than the primer (362). This retained moisture may be sufficient to produce conditions that are conducive to mold growth and corrosion. Sorption-desorption studies have shown that moisture readily passes into a paint film but that the rate of desorption depends upon the type of vehicle and its pigmentation. Some paint films were found to gain 7-10% volume moisture at 65% relative humidity and this may be related to other authors findings that accelerated mold growth and corrosion takes place above 65%. This author suggests that further investigation could establish a moisture content limit applicable to the mold and corrosion resistance of paint films (362).

Correlations between the measured water vapour permeability and the durability of the films as paint coatings have been found by several authors. McBane (363) found good correlation between the durability of paints and their diffusion coefficients but an anomalous relationship to permeability coefficient. Measured permeability coefficients for supposedly permeable and impermeable coatings did not differ very much but there were considerable differences in sorption which might explain the greater protection given to metals by some coatings. Pigmentation of the film to a high pigment volume content was found to increase the water vapour permeability (364). The permeability to water vapour of various paint systems was measured when the films were new and after weathering for different periods. It was found that permeability data provided reasonably good criteria for judging the performance of the systems tested (paint systems for wood). In most cases the permeability varied inversely with film thickness and directly with the duration of exposure (365). Measurement of the permeability of detached films of primers and complete paint systems were measured and correlating these with paints on wood it was found that certain primers became more effective as liquid water barriers when used over a water repellant treatment but lead primers were found to be more effective than water repellents (366).

Explanations of some of these results can be found in the studies by Perara and Heertjes (367) on the water transport through paint films. They describe the theory of permeation and explain the variation which they found in permeability coefficient with concentration of water vapour as being due to corresponding changes in the solubility and diffusion coefficients on which it

depends. The differences in the diffusion coefficient values obtained from steady state and transient procedures are interpreted as proof of the presence of immobile molecules of water in the film during the permeation procedure. This and the dependence of diffusion on water concentration can be satisfactorily explained by cluster theory. Permeation measures the water which actively participates in the transport process, sorption measures all the molecules taken up by the film independent of their mobility. The difference between the values is explained by water molecules being immobilised at low retention values by specific interaction with polar groups or by cluster formation at high retentions and this gives a more complete picture of the process of water transport through films. Then polymer films are subjected to osmotic pressure they act as semipermeable membranes since they are virtually impermeable to solute penetration. Osmotic measurements can be considered as an extension of the permeation measurements to the experimental conditions of a high water concentration on both sides of the film. This may be important in studies of the blistering of paint on wood. The incorporation of impermeable inert pigments in the paint films resulted in a decrease in permeability coefficient with increasing pigment volume. Where the pigment formed aggregates then the permeability coefficient increased due to the presence of air entrapped in the film except where the pigment interacted with the film (red lead - alkyd) where results were lower than expected.

Guruviah (369) measured the permeability of paint films to oxygen and water and related these to the corrosion of metal panels coated with them. The low corrosion rate of the painted panels was explained by the slow diffusion of oxygen through the film. The amount of oxygen diffusing through the film per year was found to be less than the amount known to be needed to corrode mild steel. Permeability to oxygen of all the films was much less than to water.

The kinetics of moisture transport through wood and paint were studied and the effects of the permeability of the coating considered for exterior and interior paint systems under varying climate conditions (370) a similar study was made for wood treated with preservatives (371). Wood wetted to 50% moisture content before treatment with different paint systems showed that irrespective of the type of primer used, wet wood dries very slowly through an intact 3 coat paint system and therefore the painting of wet wood or subsequent water penetration through unsealed joints gives considerable risk of wood decay (372). These reports are concerned with exterior woodwork and are not directly related to conservation work in Museums.

Boardman et al (373), have studied the effect of resin additives on the water vapour transmission rate of ethylene/vinyl acetate/petroleum wax hot melt coatings for paper. As wax coatings are often used in conservation work this might be interesting. The water vapour transmission rate was found to depend on the type of resin used, coating temperature and degree of wetting and penetration of the substance by the hot melt. The degree of crystallinity of wax and the presence or absence of microcracks is important. The nature of the modifying resin and the rate at which the coating cools on the substrate both affect the morphology of the coating through their effect on the nucleation and rate of crystallisation. Paraffin wax 75-40% microcrystalline wax 10% ethylene vinylacetate copolymer 15% resin 0-35% were used the paraffin wax being replaced by 0-35% resin. Hydrogenated petroleum polydiene resins, hydrogenated resins and rosin esters were found to give low water vapour transmission rates (373).

the commercial paints recently tested for the preservation of timber outdoors, some emulsion primers (acrylics) have been found to compare favourably with conventional primers (374), water-repellent treatment has been found to be more durable than clear varnishes (375, 376, 377, 378, 379). Polyurethane varnishes have been found to give good results when used as primers, and the importance of adequate thickness of coating 4-5 coats is stressed (380). Clear finishes based on alkyd and oleoresinous varnishes have been found to give better results than two pack, moisture curing and oil modified polyurethanes and epoxies (379). Untreated timbers were found to be unsatisfactory in appearance after weathering and oil based water-repellent stains to give good results (381) (382). Water repellent dip treatments have been found to stabilise pine window frames to such an extent that after 2 years the joints show no more movement than those made of western red cedar or Californian Redwood (383).

Failure of adhesives or lacquers on wood may be due to the effect of extractives in the wood and can be prevented in the case of polyester varnishes by applying an insulating layer of polyurethane before the polyester. Suitable species or moisture content of the wood, ultra-violet light attack, suitable application temperature, glues or stains can also cause failures. Modern lacquers and methods of application are described (384, 385). The correct choice of bleaching treatment, stains, application methods, failures and correction of these, for polyesters and other modern varnishes used in the furniture industry are described in a series of leaflets published by the Centre Technique du Bois (386, 387, 388).

The improvement of the performance of clear coatings for wood gained by incorporating ultraviolet absorbers has been shown (389, 390) and it is concluded that because of reaction differences any absorber being considered must be selected in the particular varnish in which it is to be used. The use of transparent materials (of similar refractive index to the varnish) to absorb ultraviolet light and prevent the degradation of clear varnishes has been investigated. It has been found possible to improve the life of a varnish from 2 to 10 years by incorporating cheap materials such as flyash (pulverised fuel ash, a product of power stations) and blast and iron foundry slags. An additional advantage is that when the coating fails it powders off rather than peeling and can readily be recoated (393).

The effect of light on lacquered wood surfaces has been studied using Xenon and mercury vapour lamps. Methods are described for measuring the colour changes and increased hardness caused by light. The smallest changes were found with polyester, polyurethane and acid catalysed lacquers (392).

Wainman (393) has suggested that a film forming hydrophilic barrier be used to protect wood against dimensional changes due to changes in moisture content instead of the more usual hydrophobic water barriers. The barrier must have a high affinity for wood and swell when wet so that the capillary system will close and prevent capillary flow through the film to the wood. The possibility of developing a multilayered system of coatings varying by steps from an extremely hydrophilic inner coating to a hydrophobic outer coating is being considered and experiments on such materials are in progress.

The permeability of different plastic films to water vapour has been reported (394, 395, 396, 397). Polyvinylidene chloride films (Saran) are still reported as having the lowest permeability to water vapour of all the commercially available plastics but it is not recommended for use in direct sunlight and experiments at the Victoria and Albert Museum (unreported) have shown it to become brittle in fluorescent light. Fluorocarbon films (polyvinyl fluoride

(Tedlar) and Kynast, Kynar) (398) have good water vapour barrier properties, nearly as good as Saran, have been used on buildings and are said to have outstanding durability to weathering and light. Until recently these were only available as films but recently their possible use in paints has been suggested and it maybe that clear coatings which can be applied from solvent solutions will become available and could find uses in Museum conservation (398).

Treatment of wood to improve the dimensional stability

General

A general description of the chemical and physical methods used to improve the dimensional stability of wood has been given by Laidlaw (399) at the New York IIC conference (1970). He classes the methods into groups similar to those used by other authors (see our previous reviews (400,401)).

1. Waterproof coatings.
2. Reducing the hygroscopicity by replacing the hydrophilic hydroxyl groups with hydrophobic materials.
3. Bonding chemically with crosslinking adjacent cellulose chains restricting swelling.
4. Bulking the fibres with non volatile materials to prevent shrinkage in a dry atmospheres. Most of the methods used in museum conservation such as impregnation with polyethylene glycol, epoxy, acrylic, urea formaldehyde resins, other waxes and wax resins come into this fourth class or the first if the hoped for impregnation is not achieved in practice. The second and third classes require stringent and carefully controlled conditions of treatment and are usually applicable only to new timber before it is fabricated into objects and probably cannot, and as far as we know have not, been used for museum objects.

Stamm (402) also at the IIC conference, has summarised the methods of reduction of deterioration of wood by dimensional stabilisation but gives recommendations for waterlogged wood only and for other types of museum object recommends keeping them in constant humidity conditions.

Burmester (403) has reviewed the problems of wood structure and moisture relations and considers chemical, physical and mechanical techniques also including the dimensional stability of wood products such as fibre and particle boards, plywood and other laminates.

Stabilisation with polyethylene glycols (PEG)

The method of stabilisation by bulking (impregnation) with polyethylene glycol has been in use for many years. This review will deal only with the use of polyethylene glycol on relatively dry wood around 5-20% moisture content.

Recent work with PEG 600 (404) has shown that PEG does not penetrate the cell walls of dry wood but that after swelling the wood with water, or when aqueous PEG solutions are used, penetration is achieved. The authors postulate that the dimensional stability of the treated wood is improved because at low humidities the walls remain swollen by the PEG and at high humidities by its

us solution thus maintaining stable dimensions. It was found that a PEG content equivalent to 70-85% of the normal fibre saturation moisture content required to prevent shrinkage. Aqueous PEG solutions were used to impregnate hardwoods (chilanni, gurjan, axlewood) substantially reducing the normally shrinkage of these species (404) but the authors point out that the means of efficiently treating timber of commercial sizes have yet to be investigated. Even in small sizes none of the species absorbed enough PEG for adequate dimensional stability (15% retention gave 60% antishrink efficiency percentage reduction in equilibrium swelling or shrinkage caused by the treatment i.e. shrinkage of untreated wood reduced to 60% of its original value) by vacuum impregnation to give the deepest possible penetration. The stability of PEG treated wood sweating at high humidities is often mentioned. The authors found that this only occurred at humidities above 80% RH. Treatment of Australian timbers with glycerol and with polyethylene glycols showed that significant control of shrinkage could be obtained. Glycerol was probably because of its lower molecular weight and therefore better penetration was found to be the best stabiliser. The stability was invariably improved by increasing the concentration of the bulking agent used. Surface gloss was observed when high concentrations of bulking agent were used but was considered that this effect could be eliminated by reducing the treated wood to a lower moisture content (405). The fact that better dimensional stability is obtained when the wood was preswollen and then impregnated was shown in a comparison of the efficiency of treatments with PEG, phenolic resin, acrylonitrile and methyl methacrylate on Southern pine species. PEG was found to give the best stability and low density wood gave better results than high density mature wood as would be expected (406). This pre swelling treatment is often mentioned in the literature on dimensional stabilisation (also the section on monomer treatments) and could be dangerous to museum objects. In the National Museum of Denmark (407) PEG in methanol is being used on waterlogged wood and it is suggested that a new method of dehydrating with diethyl butanol and then impregnating with waxes such as polyethylene glycol could be used on sound wood. The author points out that the porosity of sound wood is much less than that of waterlogged wood which has been dried. The fact that greater amounts of PEG can enter waterlogged wood due to its more porous structure (original hemi-cellulose having decayed) may account for the greater effectiveness of PEG as a treatment for waterlogged wood than for dry sound wood. Another reason for the greater ease of impregnating waterlogged wood is due to the direct replacement of the water already present by the water soluble PEG. Similar results can only be obtained with sound wood by first soaking it in water or by treating it in the green state.

The literature on the dimensional stabilisation of wood with PEG has been reviewed by Schneider (published in German) (408). New work of his included in the report shows that maximum stabilisation 96% has reached at two thirds of the maximum absorption and is greater in the radial than the tangential direction. At atmospheric pressure it was found that only water-soaked wood could be impregnated with PEG: cycles of vacuum and normal pressure were needed for air or oven dried wood, air dried being best for optimum PEG take-up and dimensional stability. Increasing the temperature of the water soaked wood decreased the PEG uptake and the dimensional stability obtained. Water-soaked wood was found to take up more PEG than dry but dry wood gave better dimensional stability per percentage of PEG content. No explanation of this interesting observation was given. Measurements showed that "effective dimensional stability" determined over a range of relative humidity which is likely to occur in practice is smaller than the 'nominal' value conventionally determined on a basis of maximum swelling or shrinkage of treated and untreated wood after soaking in water. This is an important point. Dimensional stability is often measured by soaking the treated and untreated wood in water, which is an

unrealistic test for Museum objects and may give misleadingly optimistic results. Strength tests showed that PEG produced no serious reduction in bending and compression strength. It caused a retardation in flame spread, a decrease in electrical resistance, slight colour darkening and sometimes an increase in the coefficient of friction.

Damage to complex structures is related to swelling pressures as well as to dimensional stabilities recorded as the movement of free-standing specimens. The swelling pressure in tangential and radial directions of beech impregnated with 10, 12 and 40% of polyethylene glycol 1500 has been determined after immersion in water for three hours (409). At 40% PEG tangential swelling pressure was 17% and radial 2% of those of the untreated wood. If these differences also hold for humidity changes below actual soaking then the results are important in the use of modified wood; in that as well as dimensional stability (less swelling and shrinking) the pressure of any movement which does take place also being lower will cause less damage to complex structures. These results would be expected in that PEG treated wood behaves like wood water moistened to the degree of swelling caused by the PEG. Because of the bulking effect of the PEG in the fibres the wood is already swelled (bulked) and further swelling is not so great as unswollen wood and the swelling pressures are lower.

In situ polymerisation of monomers by radiation

A survey based on the world literature and on experimental work carried out by Czиковski (410) has considered all the main aspects of wood/plastic combinations produced by radiation polymerisation. Processing properties and economic possibilities are discussed and polymerisation by radiation compared with chemical methods of polymerisation.

The effectiveness of gamma and electron irradiation (10 Mev from a powerful linear accelerator) have been compared (411). Gamma irradiation (dose 200 K rad) was found to be 10 times more effective than electron irradiation. Higher doses were required to polymerise the substance (methyl methacrylate, vinyl acetate and styrene monomer) in wood than for the monomer alone. Required gamma radiation doses differed only slightly between the different species of wood tested (Norway spruce, Scots pine and beech).

The swelling of wood caused by impregnation with the monomers could be a problem in treating museum objects and some papers discuss this. The swelling rate of wood in various vinyl monomers has been measured; loblolly pine was the species used and the monomers methyl methacrylate, styrene, acrylonitrile, ethyl acrylate and binary mixtures of these. It was found that the moisture content of the wood had a dominant effect on the swelling observed; at 15% moisture content the wood was dehydrated by the monomer and shrank whereas at 5% moisture content the wood swelled. The swelling at low moisture content was explained as being due partly to the wood adsorbing water from the monomer and also to the monomer itself being adsorbed. The swelling obtained could be as much as 2% for very dry wood but was normally of the order of 1% (412). Sian found greater volumetric swelling with Basswood impregnated with methylmethacrylate, styrene and tertiarybutyl styrene; values of up to 9% being observed. When the monomers were polymerised antishrink efficiencies of up to 40% were obtained. The results were considered to show that the monomer enters the cell wall before polymerisation. His comparison of results with literature data showing that large differences in swelling are found between different species probably explains the differences between this work

) and (412). Alksnis (414) has shown that oven dry wood (birch) swells times as much in methyl methacrylate as in styrene but with increasing moisture content swelling in the monomer decreased and at a certain point the negative which agrees with the results given in (412). Preliminary vacuum treatment accelerated the uptake of monomer but did not increase the amount in the wood.

Study of the penetration of monomers into wood (415) has shown that penetration into birch wood is a long term process and is not subject to the usual laws of diffusion. Decreasing the polarity of the monomer molecule was found to decrease the speed of its penetration into the wood. The penetration of methyl methacrylate alone and with added solvents into Hinaki wood in different grain directions under vacuum has been followed using a fluorescent dye; but in this work the monomer was polymerized with benzoyl peroxide (416). The penetration was found to be greater axially and least laterally where the growth ring boundaries tended to act as barriers in the wood. Methanol as solvent caused normally less permeable rays to be penetrated but reduced penetration generally, benzene and dioxane showed less marked effects. Extraction of the wood with benzene and alcohol, removing resins and other soluble materials, before monomer treatment increased the penetration into heartwood laterally and also sapwood radially when added solvents were also used. Benzene and alcohol extraction was used by another author (404) to increase PEG penetration into Red Lauan.

Temperature increase (50-100°C) which occurs during the polymerisation of monomer in wood could be damaging to museum objects. Davies et al (417) have shown that a 10:1 reduction in dose rate lowered the maximum temperature rise by 25°C. Different amounts of methyl methacrylate in the wood (Red pine, yellow birch) and different doses of gamma radiation were examined. It was found that the temperature rise reached a maximum near the completion of polymerisation and could be used to indicate the state of the reaction. With increased loading of monomer the polymerisation rate, which increased during the reaction, was greater and the radiation required to complete polymerisation lower (see also 12).

Studies of the distribution of monomer in the wood structure and examination of the bond, if any, between the wood and the monomer have continued. Some previous work can be found in our reviews (400). Whether a monomer has penetrated the cell walls in the wood fibre and formed a polymer there, or not, and whether this polymer is chemically linked to the cellulose or lignin, or is physically entangled with the molecules of the wood substance has been discussed for some years now with no definite conclusions being drawn. The monomer which is used, the method by which it is deposited in the wood substance and polymerised, the use of solvents as swelling agents and many other factors make this an extremely complex subject. Timmons et al (418) have developed visual methods to locate a vinyl polymer in the structure of a wood polymer composite and used autoradiography (using radioactive isotopes incorporated in the monomer) at the light microscope and electron microscope level to locate the polymer with respect to the cell wall and its individual layers. Solvent exchange impregnation was found to allow monomer diffusion into the cell wall and subsequent polymerisation in situ with the greatest monomer concentration in the compound middle lamella. Electron microprobe studies showed that 19% of the polymer was exchanged into the solvent swollen cell wall. Oven dried wood had relatively impermeable cell walls and pentane swollen wood contained 25% less polymer in the cell walls than wood preswollen with a solvent. Using the scanning electron microscope it was found that the polymer was closely associated with the wood and altered its mode of fracture, oven dried wood cell walls failing in a fibrous manner whereas polymer

impregnated wood failed in a ductile or brash mode depending on the glass transition temperature of the polymer (418). Styrene alone was found not to penetrate the cell walls of the wood (beech) but did penetrate when methanol was used as a solvent for the styrene. When the cell walls were not impregnated swelling of the treated wood in water was similar to untreated wood, but when the cell walls were impregnated swelling in water was considerably reduced (414). Another report, (419) also shows that the dimensional stability of the wood is determined by the amount of polymer in the cell walls and that polymer in the lumen reduces water absorption and speed of swelling. Complete dimensional stabilisation of wood with styrene and methyl methacrylate was thought to be impossible because the free hydroxyl groups in the wood retain the ability to swell by 3-4%. The amount of polymer grafted onto the wood substance depends upon the size of the internal surface of the wood accessible to the monomer (419). Other Russian work (414) has also shown that in birch wood a chemical bond is formed between styrene and the lignin during polymerisation. Methanol was found to increase the amount of styrene grafted to the wood and to increase the mean length of the polymer chains grafted onto the lignin. The speed of polymerisation of styrene was found to be greater in wood than styrene alone and depended only slightly on the intensity of the radiation (see 411) which deals with the dose required for polymerisation in and out of wood). Significantly for the use of polymers to stabilise museum objects, changes in shape of the specimens occurred during the grafting of the polymer onto the wood. However the specimens were small to start with and were not restrained from distorting during the process. The existence of a chemical bond between birch wood and styrene was confirmed by treating the wood polymer composite with acids, alkalis, solvents and by other chemical reactions. In these experiments the polystyrene was considered to be chemically bonded to the lignin and the carbohydrate constituents in the wood (414). Vinyl acetate was not found to form a graft copolymer with birch wood under the conditions used by other experimenters (414), but the authors considered that the existence of the grafting of polystyrene to wood was shown by an increasing radiation dose increasing the percentage of polymer chemically bonded to the wood. The addition of carbon-tetrachloride and/or benzoyl peroxide reduced the amount of graft copolymer formed (possibly because both provide free radicals accelerating the formation of pure polymer, reviewers comment. With an increased degree of grafting the water absorption of the treated wood decreased and its dimensional stability increased. It has been found (420) that the radiation dose needed to polymerise styrene in birch wood can be reduced $2\frac{1}{2}$ fold by adding 5-10% of vinyl acetate to the monomer but it is not reported whether the degree of grafting is also reduced.

The properties of wood plastic composite such as bending, compression and shear strength, hardness, sanding properties, and antishrink efficiencies have been measured. The bending strength of Southern Pine/methyl methacrylate combinations has been found to reach a maximum at a polymer loading of about 0.45g/g and decreased at higher polymer loadings. Moduli of rupture and elasticity were plotted as functions of untreated wood specific gravity (polymer loading and retention were found to be inversely proportional to the wood specific gravity). In all cases the treated wood samples were found to be stronger than the untreated ones (422). Gamma radiation alone with no monomer present was found to have very little effect on the hygroscopicity of wood exposed to it, at low doses the bending strength was not affected but at high dosages it declined rapidly (423). Shear strength measurements on yellow poplar heartwood impregnated with polymethyl methacrylate showed increases in the maximum strength of 66% over that of untreated wood when fully loaded with polymer and 30% when half loaded. Addition of plasticiser to the methyl methacrylate gave lower strength increases. The presence of polymer in the coarse capillary structure increases the shear strength over untreated wood, the greater the amount of polymer in the wood the greater the increase. The

of polymer also has an effect on the shear strength of the composite (424). Irradiated control containing no polymer was included in the series but no significant differences were found between it and untreated wood. Presumably dose rate was too low to damage the wood (see 423). Polymerisation with methyl methacrylate was found to increase the hardness, compression strength and bending strength of beech wood and reduce the swelling in water to 60% of that of untreated wood (425). The authors found pure methyl methacrylate to give better results than methyl methacrylate with carbon tetrachloride or methanol (see 414). Measurements of the same properties but using methyl methacrylate and styrene in pine and other woods gave similar results. The resistance to decay fungi was also measured and found to be greater than that of untreated wood (426). Studies of the dynamic mechanical behaviour of birch impregnated with polymethyl methacrylate over a range of temperatures have shown it to be sensitive to residual moisture especially at low temperatures. The impregnation decreased the elastic modulus of the wood and gave a dynamic mechanical spectrum having features in common with that of polymethylmethacrylate and that of untreated wood (428). The dimensional stability of loblolly pine and yellow pine impregnated with polystyrene acrylonitrile was found to be much greater than that impregnated with methyl methacrylate (429). This was attributed to the swelling during treatment of 2-7% thus creating a bulking action. Test results were given by 50% loadings, higher loading caused shrinkage stresses of shrinkage 1.5% during treatment) which led to swelling when subsequently exposed to moisture (see 409-413). A comparison of the physical properties of irradiated and chemically cured wood polymer composites has shown that there is very little difference between them. Peroxide curing is said to be satisfactory for small pieces but larger ones heat up causing damage, retarding chemicals can be used to reduce the likelihood of this occurring. The composites are said to be not weatherproof; the surface drying and shrinking more rapidly than the interior loosens the fibres and combined with the bleaching of unimpregnated wood fibres leaves the surface bleached, fuzzy and grey after only a few months. During polymerisation window frames were said to warp badly and excess material to be required to allow for final machining to shape to correct the distortion (430). Other authors have not mentioned these defects which must depend on the polymer chosen and the method of treatment. The thermoplastic character of the polymers gives trouble when a wood polymer composite is sanded during processing (and may be partly responsible for the poor weathering mentioned above). The incorporation of 1% of 1,3 butyl dimethacrylate or vinylbenzene copolymerised with the methyl methacrylate used as the main polymer raises the melting point of the polymer and makes sanding, drilling and turning much easier (431). A technique for impregnation of wood with vinyl monomers has been described. Most of the monomer penetration was shown to be in the early wood where the hardness was increased by 50% as against 10% for late wood (432). Work on the antishrink efficiency of Southern pine impregnated with polyvinyl chlorides and polymethyl methacrylates has shown that the high initial values fall considerably during prolonged soaking. This indicates that impregnation although reducing the rate of swelling confers no permanent stability. There is not a relevant test for museum objects which will not be subjected to soaking for several hours. A university thesis (433) discusses a method of predicting the properties of a given wood plastic composition from the corresponding properties of the wood and the polymer determined separately. The analysis was carried out for uniform soft textured softwoods where a physical model of an infinite matrix with regularly spaced elliptical voids could be used. The extension of the method to other types of wood is outlined.

The absorption of a variety of liquids into small dry samples of *Pinus radiata* after immersion, with or without ultrasonic radiation (40KHz) was measured. Non polar liquids such as paraffins and aromatic hydrocarbons showed no increase in capillary penetration but straight chain hydrocarbons with hydrophilic groups especially when diluted with water showed increased penetration when ultrasonic

waves were applied. The authors attribute the increase in penetration using supersonic waves to the formation of minute bubbles by the supersonic treatment, thus making de-gassing easier and quicker, and conclude that in fields where rapid and thorough impregnation of wood by liquids is required supersonic waves can aid the process and be of practical use (434).

Catalyst polymerisation

The percentage resin loading obtained in a large range of different woods using a low viscosity solution of polymethyl methacrylate in methyl methacrylate monomer has been measured using peroxide catalyst and heating to 50-60°C. The physical and mechanical properties of various polymer wood combinations have been measured and compared with untreated woods. Experience in the production of polymer wood by catalyst polymerisation has been summarised for commercial production, cost, improvement in properties per percentage volume of plastic etc. Birch and beech are considered to be the best species for impregnation, conifers to be the least suitable (435). Thermocatalytic polymerisation of styrene and acrylonitrile (60:40 combination) in the cell cavities of wood without grafting has been shown to give similar retention by weight, dimensional stability, hygroscopicity and hardness to similar compounds produced by radiation polymerisation (436). Styrene polymerised in wood by heating to give a 28% increase in wood density has been shown to give a swelling decrease of 75% compared with untreated wood (437). Static bending, compression and toughness tests for wood (basswood) impregnated with methyl methacrylate polymerised by a catalyst heat technique showed its strength values to be 25-150% greater than untreated controls. The polymer filled 71% of the voids out of a possible maximum of 79% (the monomer evaporates during polymerisation reducing the theoretical 100% filling of voids to 79% (438). Munnikendam (439) has reported a way of reducing the evaporation of monomer during curing by immersing the treated specimen in water or glycerol made into a gel with starch, kaolin or carboxymethyl cellulose during polymerisation with organic peroxides. 94% monomer retention was obtained, a slight retraction of the polymer into the surface meant that there was no visual change in the treated wood. If more surface hardness was needed a treatment with polymethylmethacrylate in acetone or soluble nylon in ethanol was used after the impregnation polymerisation procedure. Hot water extraction of the wood before treatment was found to increase the degree of graft polymerisation between styrene and wood, the wood extractives were considered to act as retarders by inhibiting decomposition of the peroxide catalyst used. These experiments were carried out on wood fibre and flakes, the method of extracting with hot water before treatment might not be possible for larger pieces of wood (440). Kenaga reduces loss of monomer by using high boiling styrene type monomers (vinyl toluene and t-butylstyrene and monochlorostyrene) (441).

If treatment with monomers were to be used on museum objects the creep and stress relaxation of the wood plastic combination produced might be important. this has been measured for lime wood treated with methyl methacrylate monomer polymerised with organic peroxide and heat (442). The material was subjected to loads corresponding to 20, 40, 60, 80% of its short term bending strength for periods up to 96 hours. The creep compliance of the wood plastic was 35-55% of that of natural wood and 10-22% of that of the pure polymer. Increase in resistance to stress relaxation of the wood polymer was 180-300% times that of untreated wood and 200-400% that of the pure polymer. The wood fibres are strong and have a high modulus of elasticity, the pure polymer has a low elastic modulus, mutual interaction of both components in the stressed state prevents the spreading out of cracks and fissures as well as restraining the freedom of displacement of the wood structure and hence decreases creep and

stress relaxation. This suggests that wood plastic composites as well as being less under humidity changes than natural wood will also move less under stress (442).

Four phase treatments

Review (443) describes the impregnation of wood with chemicals in the gaseous phase as having the advantage of high transport rate and much more even distribution than liquid treatments. However large quantities of material cannot be distributed rapidly as the use of gaseous methods will probably be limited to applications requiring only a small quantity of chemicals evenly distributed through the wood substance. Gas phase polymerisation has the advantage of fixing polymer on and within the cell walls where it condenses without blocking the lumens and vessels and therefore the weight increase will be much less than that for liquid methods and there will be no bulking. Suggested materials are polypropylene oxide which is hydrophobic and chlorinated polyethylene a rigid crystalline film former which might form a homogenous coat on the cell walls thereby limiting moisture sorption and swelling and giving dimensional stability. Formaldehyde is also a possibility when used with a weak base or as a catalyst and not an acid which would embrittle the wood. The importance of selecting the right impregnant and impregnation method to give the required properties to the wood polymer composite is stressed. Formaldehyde gas treatment followed by hydrochloric acid gas as catalyst was found to lead to an improvement of dimensional stability due to the formation of chemical bonds with hydroxyl groups in the wood. Even normally impermeable woods could be treated but some embrittlement of the wood occurred due to the action of the acid catalyst (444). Impregnation of beech wood with tannin solutions caused reductions in swelling with moisture of about 20% and subsequent treatment with gaseous formaldehyde at 130°C caused a further reduction in swelling and shrinkage which is attributed to both bulking and cross-linking effects. The improvement in properties is achieved with a relatively small uptake of chemicals. Dimensional stability can be further improved by treatment with hydrogen chloride gas after the formaldehyde (444). In a continuation of this work oak heartwood was steamed to reactivate the tannin present in the wood and then treated with gaseous formaldehyde which reacted with the tannins in the presence of acids liberated by hydrolysis. The relative tangential swelling with moisture was reduced by up to 80% compared with that of untreated wood. The method can be used for the stabilisation of other woods with normally impermeable heartwoods and similar but less marked results have been obtained with chestnut, teak, Robina, beech and hornbeam (44). Sulphite waste liquor was used alone and in combination with formaldehyde in an attempt to reduce adsorption and capillary condensation when the formaldehyde reduces the chemical adsorption of water by the wood. Soda, tannin and sugar treatments were also tested and most increased the fibre saturation point whereas formaldehyde reduced it and partially counteracted the effect of the other substances when in combination with them. None of these processes yielded a satisfactory treatment for the dimensional stabilisation of wood except the tannin formaldehyde treatment (see 444, 445, 446).

The stress relaxation in bending of acetylated (acetylation - acetic anhydride treatment which replaces hydroxyl groups on the cellulose molecule with acetyl groups) wood was tested in the water saturated condition, the results of variation in the stress relaxation behaviour at different acetyl values (different numbers of hydroxyl groups acetylated) and temperatures led to the conclusion that in watersoaked wood the hydroxyl groups have an important influence on the relationship between temperature and stress

relaxation. This work was carried out to study the behaviour of the hydroxyl groups in wood rather than to stabilize wood by acetylation (447). The treatment of wood with acetic anhydride, butyl, allyl, t-butyl and phenyl isocyanates under various conditions of time, temperature and moisture showed that acetic anhydride and butyl isocyanate improve the dimensional stability of the wood giving 60% antishrink efficiency. Dimethylformaldehyde (DMF) increased the reaction rate with acetic anhydride and DMF or another swelling agent in which butyl isocyanate is soluble was found to be necessary to get good results with this material. The treated wood retained 80% of the toughness and abrasion resistance of the untreated wood (448). Di-isocyanate uptake into pine and beech timbers was found to decrease with increasing moisture content. Hardening of the di isocyanate occurs through reaction with water in the cell wall forming polyurea and not with the hydroxyl groups in the wood. The treatment caused shrinkage of the wood material initially (449). Beech wood dried by the WAN (Water alcohol non-polar substance) method, in this case methanol/pentane, in such a way that it retains its swollen dimensions corresponding to 7-12% moisture content although the water has been removed, takes up 35% more toluene 2:4 di isocyanate than wood dried normally. Part of the di isocyanate penetrates the cell walls and forms chemical links with the wood substance (no water present so not the same as ref(449) giving 35% improvement in dimensional stability in the water soaked condition and higher antishrink efficiencies in alternating humidity conditions eg: 50% at 34-97% RH oscillations. The better results obtained in these than in previous experiment was thought to be due to penetration of monomer into the cell wall and it is planned to apply this process to other monomers (450). Ethylene oxide vapour with trimethylamine as catalyst has been shown to reduce the hygroscopicity of Southern pine wood, high antishrink efficiencies were obtained with low polymer loading. Vinylchloride treatment was not so successful. An oscillating pressure technique was found to give better penetration than constant pressure treatment (55).

Impregnation with synthetic resins and other materials

In general these substances fill only the voids in the wood and do not penetrate the fibres or cell walls. They do not fall into any of the 4 classes described by Laidlaw (see p33. and our Amsterdam report 1969 (400)) although some bulking may take place. Elizabeth Packard reviews the methods that have been used to consolidate decayed wood sculpture and discusses their relative merits. Experiments have shown that wax darkens the wood, must be applied hot and gives poor glueing and paint reattachment after treatment; Xylamon has good penetration but darkens the wood; Saran polyvinyl chloride - acrylonitrile) is difficult to dissolve or redissolve and the solvents for it attack paint, it is best used on a smooth surface; as a moisture barrier than as a void filler. Acryloid B72 and soluble nylon because they must be applied in dilute solutions give considerable weight loss after treatment due to evaporation of solvent; epoxy resin (Glit Rot) hardens too fast to penetrate large cross sections but penetrates end grain and is drawn in by capillary action, it is irreversible and as yet untested on polychrome sculpture. Practical examples are given of the impregnation of wood sculptures with wax/-resins and of impregnation with Xylamon XL using the infusion (drip feed through hollow needles) method used in Austria (452). In a review of the methods of conservation of wood in old buildings methacrylates, polyvinylacetates polystyrene and Vinoflex (vinyl chloride copolymer) are suggested for consolidation of decayed wood (453). Polyvinylacetate and methacrylates are mentioned in the new edition of Dr Plenderleith's book but he points out the disadvantage of having to apply many coats of dilute solutions to get good penetration and then allowing the solvent to dry out. When epoxy or polyester resins which

When no solvent are used no such problem arises. The use of wax resins as consolidants and the method of impregnating wood sculpture with them is described (454).

Resin impregnation is often used for wood sculpture especially when worm damage has opened up the wood structure so that the wax can penetrate. As Ballestrem has described its use on a XIVth polychrome sculpture (455). A bibliography of polychrome sculpture gives references to examples of the preservation of such sculptures where waxes and synthetic resins have been used (456). Marconi (457) also discusses the technical problems of the conservation of polychrome sculpture and gives examples of treatment which has been carried out. A microcrystalline wax and resin 3:2 mixture was used to impregnate a wooden image from Nepal made of Himalayan ash which had been attacked by insects and was spongy and fragile (458). Beeswax was used to treat a tempera painting on wood where sodium silicate had previously been used unsuccessfully and could not be removed. The lime panels were infused with beeswax to protect them against the high response to humidity induced by the old treatment (459). Christensen (407) has suggested that a method used for waterlogged wood, dehydration with tertiary butanol and then impregnation with wax in a solvent could also be used for sound wood but says that the density, when dry, of sound and previously waterlogged wood are very different, waterlogged wood being much more porous than sound wood.

Professor Caprara has used an acrylic resin Paraloid B72 (Acryloid B72) to impregnate decayed wooden objects (460,461). Mihailov has also used Paraloid for impregnating wood. He mentions also as possible consolidants Calatonoluble nylon, polyvinyl acetate and Xylamon LX. Some of these may have been used as coatings rather than impregnants (462). Xylamon LX and Paraloid solutions have been used either injected into holes in the wood or brushed on. The penetration of these materials was measured by X ray photography. Consolidation with beeswax and rosin and beeswax rosin and polyethylene glycol mixtures were found to give good results on wood damaged by fire but were not so good as Paraloid B72 (463). Austrian workers have described their impregnation method using hollow needles tubes and clamps to feed the material slowly into many holes. Careful adjustment of the rate of the drip feed is essential, the position of the needles must be changed often and any leakage from the needle holes wiped off immediately so that it does not stain the surface. The complete, deep impregnations obtained have been very satisfactory. Comparisons with other resin and wax treatments are given. A new preservative and hardener yet commercially available is mentioned which gives less darkening of the wood than Xylamon (464).

DeWijks recommends a low viscosity epoxy resin Araldite CY2/9 in preference to other synthetic resins for the hardening of rotten wood sculpture and the panels of panel paintings (465). In Czechoslovakia an epoxy resin Epoxyd 1200 has been used to consolidate a polychrome sculpture (466). Vinoflex MP400 polyvinyl chloride copolymer resin made by BASF was used to impregnate 17th century oak carvings using a vacuum impregnation method 8 years ago; the carvings are said to be still in perfect condition. Physical tests showing the improvement in properties of treated over untreated wood are given in the report (467). Polyvinyl acetate was used as a consolidant for a Japanese wooden sculpture with original gesso and gold leaf in the Baroda Museum (468). The wooden portions of turquoise covered masks were impregnated with a synthetic resin to consolidate them. Unfortunately the type of synthetic resin is not mentioned (469).

Vacuum impregnation of Douglas fir, Fuma and Lauan timbers with aqueous polyurethane resins (Nopcothanes) of low viscosity and high solids content was found to give good dimensional stability after curing at 300-325°F, green timber gave better results than dry timber. The effectiveness of the treatment was found to vary considerably with the species of timber used. This treatment would probably be of more use in the waterlogged wood field than that of dry wood. For dry wood the swelling due to using aqueous solutions, darkening of colour during the high temperature curing and differences between species, where often an object is made from several different species used together, could make it difficult to use these resins (470).

Epoxy prepolymers were used by Erika Schaffer to consolidate decayed softwoods. Impregnation with the epoxy prepolymer dissolved in glycidyl ether and toluene and subsequent polymerisation in situ was found to cause practically no expansion of the wood in contrast to polyvinyl acetate in alcohol solution. Because the treatment does not cause swelling or shrinkage it causes no stress to the wood material or any paint coating which may be present. The epoxy prepolymer has low viscosity and does not need long impregnation times, vacuum impregnation or injection as do other resins and can be applied by brushing. The depth of penetration of the resin can be varied as required. Polymerisation of the epoxy in situ gives good mechanical strength and dimensional stability. These materials sound like the ideal consolidants for museum use, experiments with similar materials are being carried out at the Victoria and Albert Museum with help from Miss Schaeffer and no doubt other conservators are also examining them (471).

Where these materials fill the voids only and do not impregnate the wood fibres, or penetrate the cell walls or react chemically with the wood substance, there may be a danger of creating a stress situation. This would arise from having in the matrix of a wood object a substance, synthetic resin, which does not move like wood in response to humidity. The wood substance, being unmodified by the presence of the resin, will continue its movement in response to humidity changes and if it is restricted in this movement by the solid bulk of the resin stress will be caused. It may be that the wood fibre is so surrounded and coated with resin that it will be unaffected by humidity changes but few resins provide a complete barrier to the movement of moisture vapour.

BIBLIOGRAPHY

The titles of all the references are given in English, those in square brackets being translations. The original language of the paper and summaries are given at the end of the reference,

eg. [Fr, de, en]

Cz - Czechoslovakia

De - German

En - English

Es - Spanish

Fr - French

It - Italian

Afr - Afrikaans

Ja - Japanese

Ne - Dutch

Pe - Polish

Pt - Portuguese

Ru - Russian

Sv - Swedish

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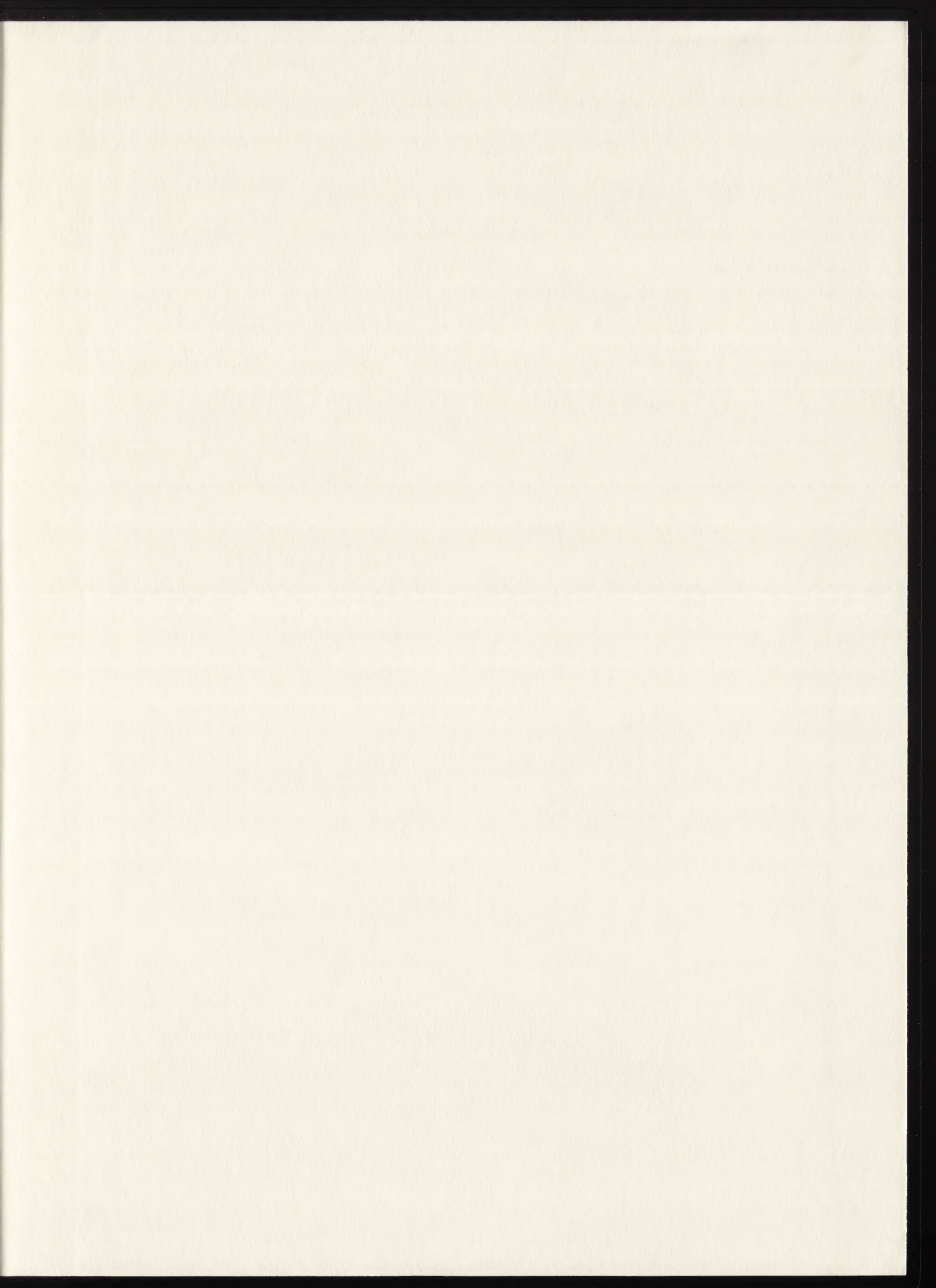
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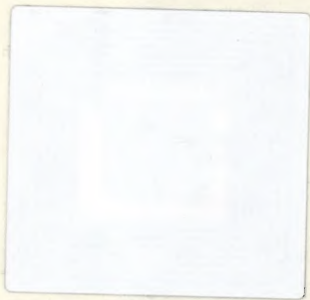
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